

Synthea

Synthetic Patient Generation

Dylan Hall – dehall@mitre.org

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FFRDCs assist the United States government with:

- Scientific research and analysis
- Development and acquisition
- Systems engineering and integration

Department of Defense
Federal Aviation Administration
Internal Revenue Service
Department of Veterans Affairs
Centers for Medicare & Medicaid Services
Department of Homeland Security
Administrative Office of the U.S. Courts
National Institute of Standards and Technology

We also have an independent research program that explores new and expanded uses of technologies to solve our sponsors' problems.

THE U.S HEALTHCARE SYSTEM: WORST IN THE DEVELOPED WORLD

U.S. lags behind in healthcare innovation

True interoperability 'not even close'

High Demand for EHR Datasets

*Non-clinical or secondary uses including:
software development, testing, clinical training where realistic data is required*

Restrictions

Real patient records carry privacy, confidentiality, consent, policy, and legal restrictions

Privacy Risks

Deidentified and anonymized records have been successfully reidentified

Cost

EHR datasets are difficult to obtain.

Anonymized records are being bought and/or sold by federal and state health departments, hospitals, health insurers, pharmacists, government lobby groups, marketers, and data brokers



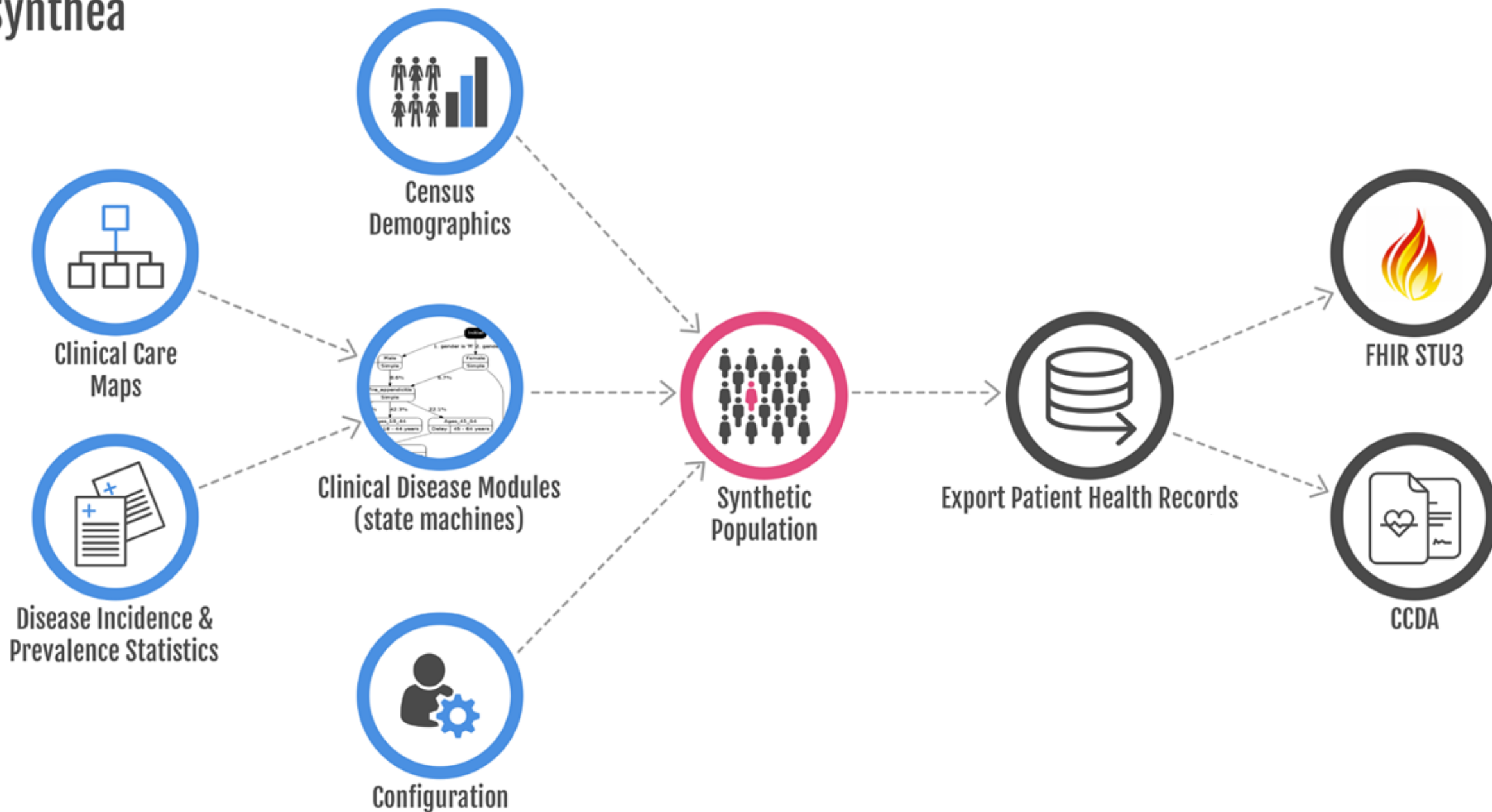
SYNTHEA

Synthetic Patient Generation

Realistic Health Data

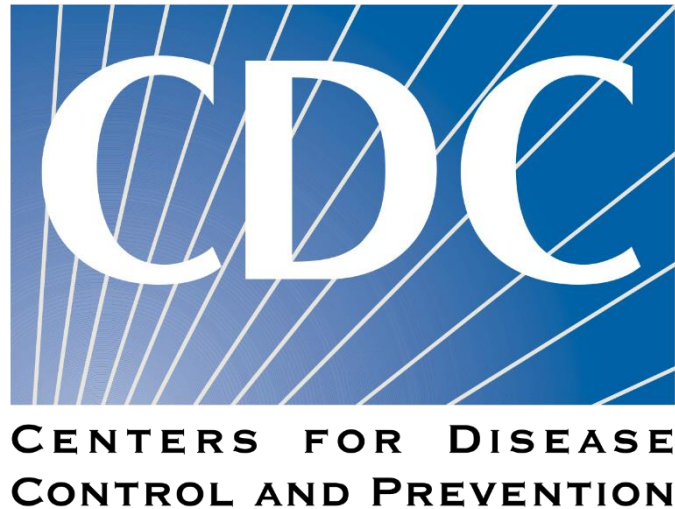
No Cost, No Restrictions

Synthea



Reasons Patients Visit PCP		Causes of Premature Death (Years of Life Lost)
Routine Infant/Child Health Check	1	Ischemic Heart Disease
Essential Hypertension	2	Lung Cancer
Diabetes Mellitus	3	Alzheimer's Disease
Normal Pregnancy	4	COPD
Respiratory Infections (Pharyngitis, Bronchitis, Sinusitis)	5	Cerebrovascular Disease
General Adult Medical Examination	6	Road Injuries
Disorders of Lipoid Metabolism	7	Self-Harm
Ear Infections (Otitis Media)	8	Diabetes Mellitus
Asthma	9	Colorectal Cancer
Urinary Tract Infections	10	Drug Use Disorders

Publicly available data sources



Clinical Pathways

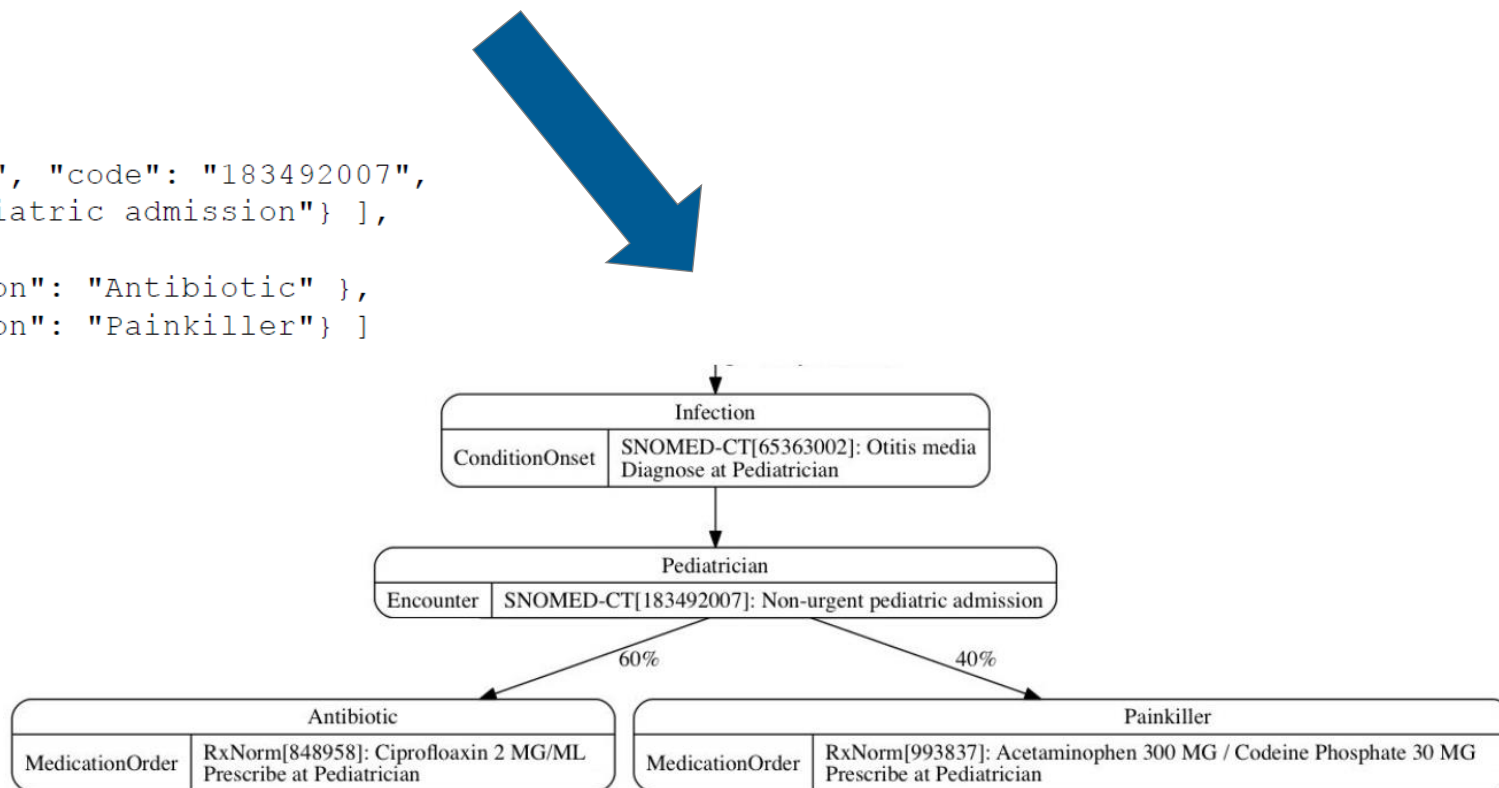
a.k.a.
care pathways,
critical pathways,
integrated care pathways,
care maps,
clinical practice algorithms

Modules are written in JSON

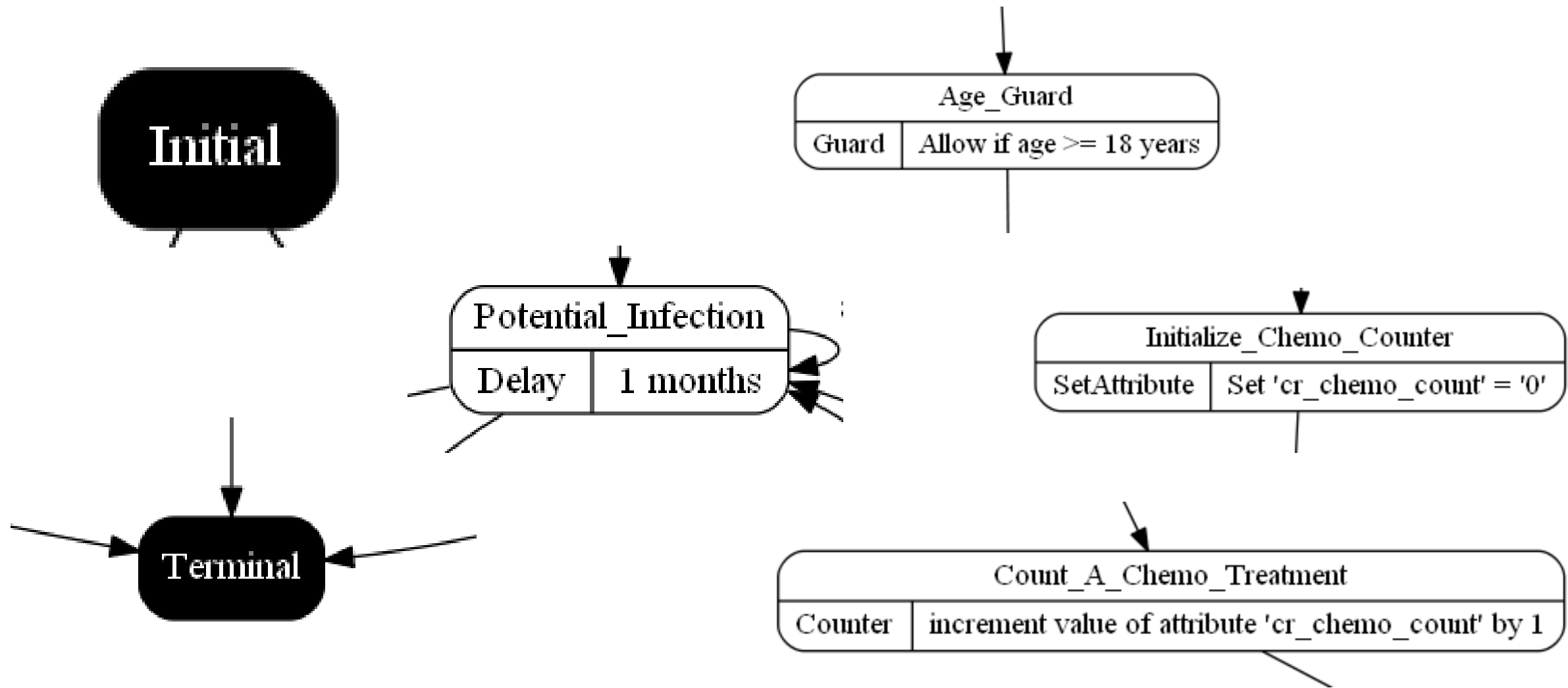
```

"Infection": {
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  "target_encounter": "Pediatrician",
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  "direct_transition": "Pediatrician"
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  "encounter_class": "ambulatory",
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    "display": "Non-urgent pediatric admission" } ],
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}

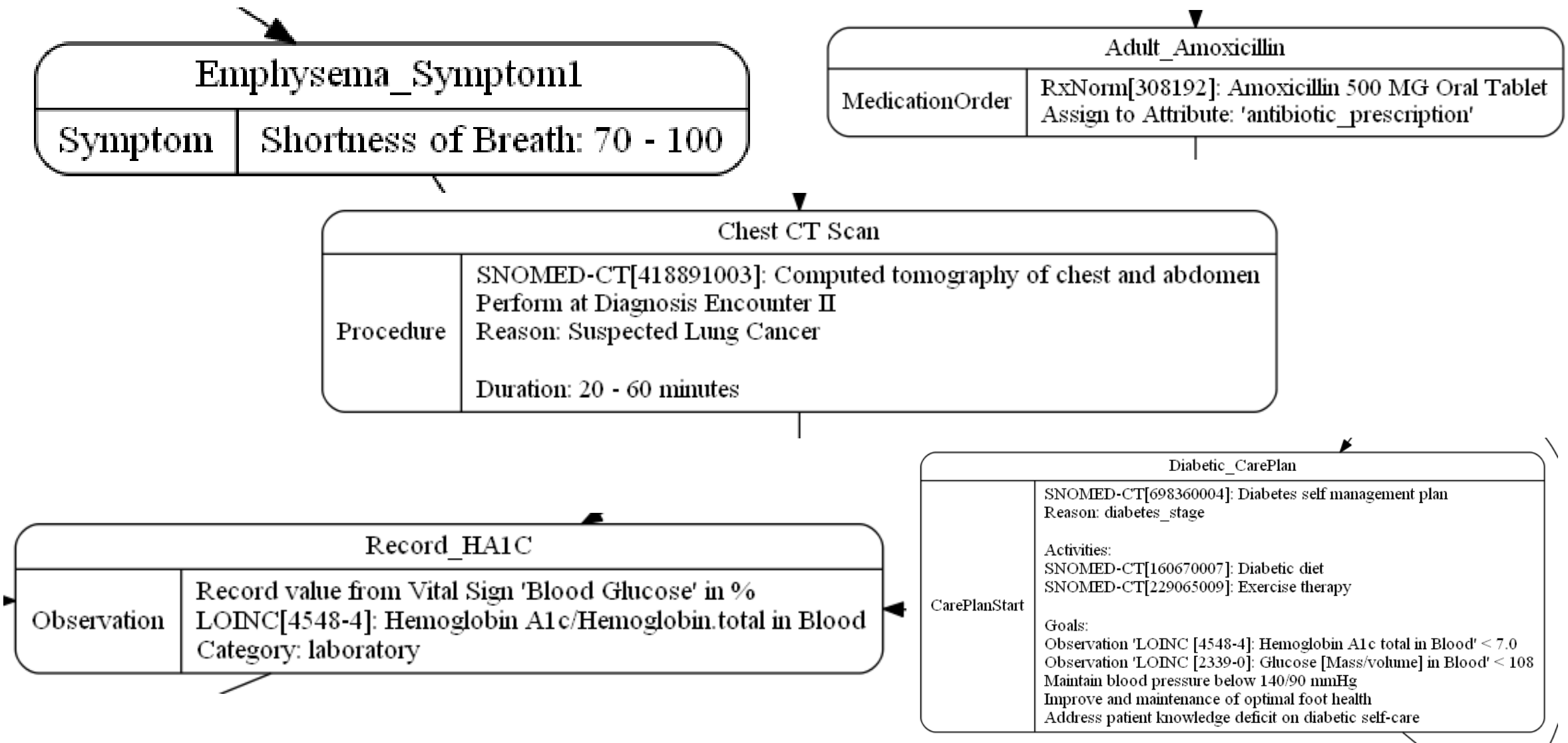
```



Control States control the flow through the state machine



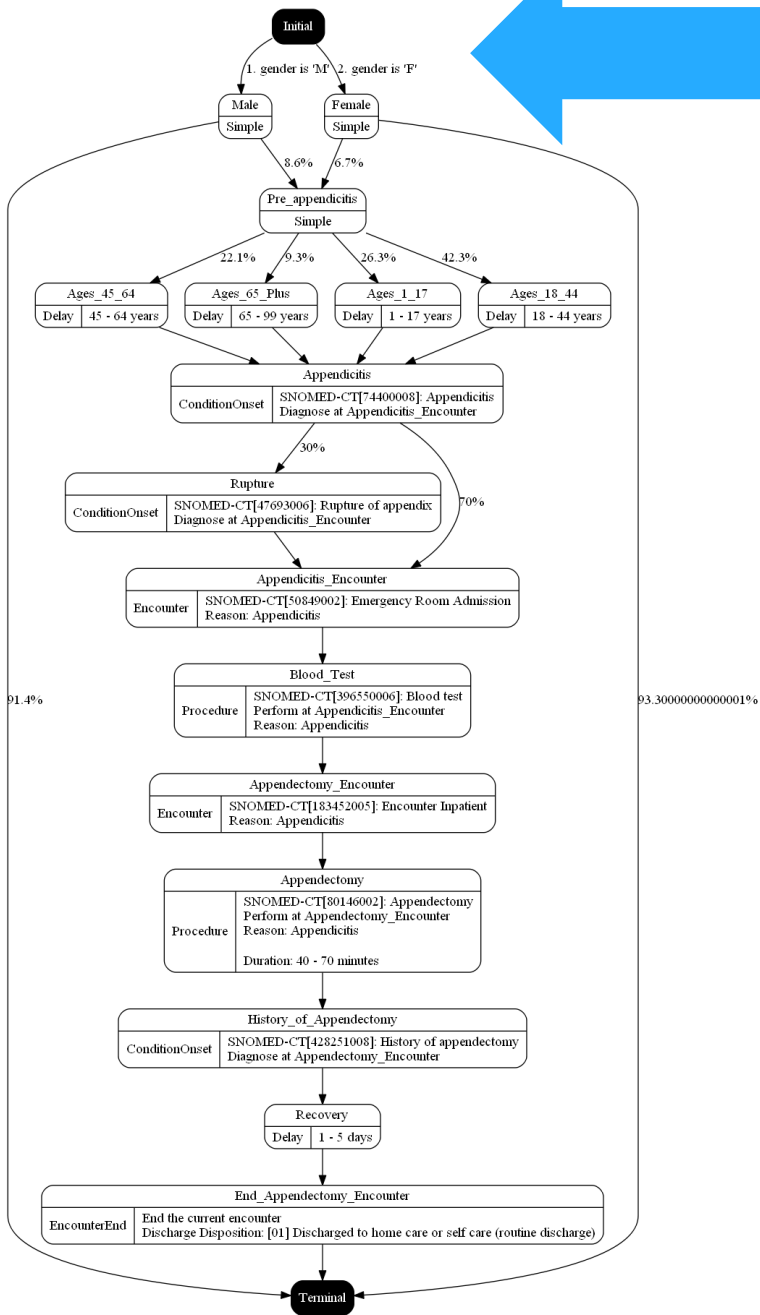
Clinical States drive the progression of disease and care



Model Validation

*Conditions and comorbidities:
Population - Incidence and prevalence
Individual - Frequencies and progression*

Example Module – Appendicitis



Smith292, John949

Born: March 25, 1947

Gender: Male

Encounters:

Conditions:

Procedures:

Smith292, John949

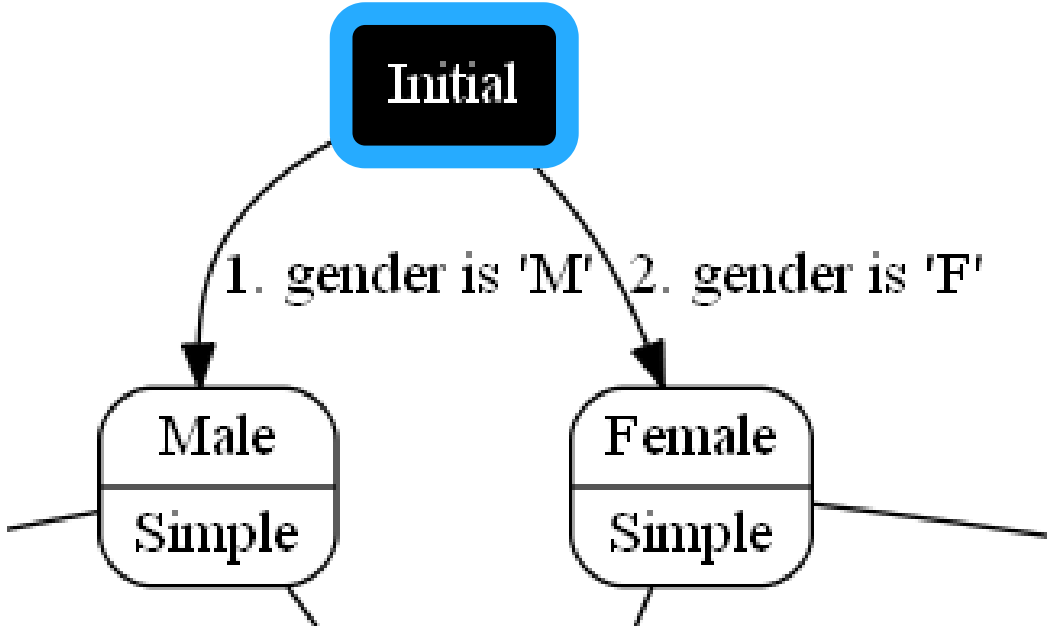
Born: March 25, 1947

Gender: Male

Encounters:

Conditions:

Procedures:



Current Date of Simulation:
March 25, 1947

Smith292, John949

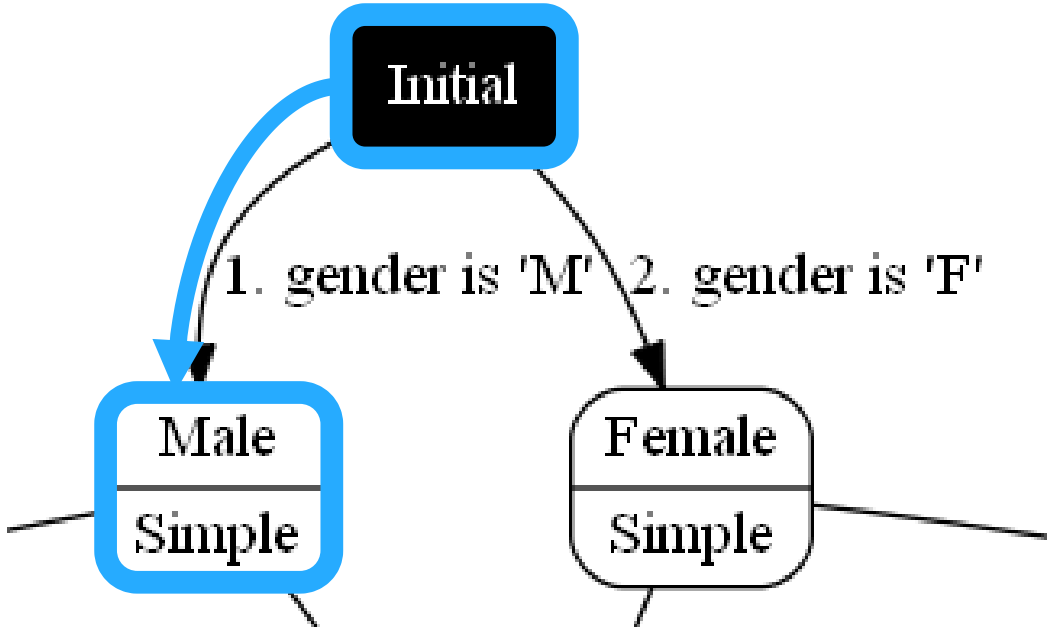
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Current Date of Simulation:
March 25, 1947

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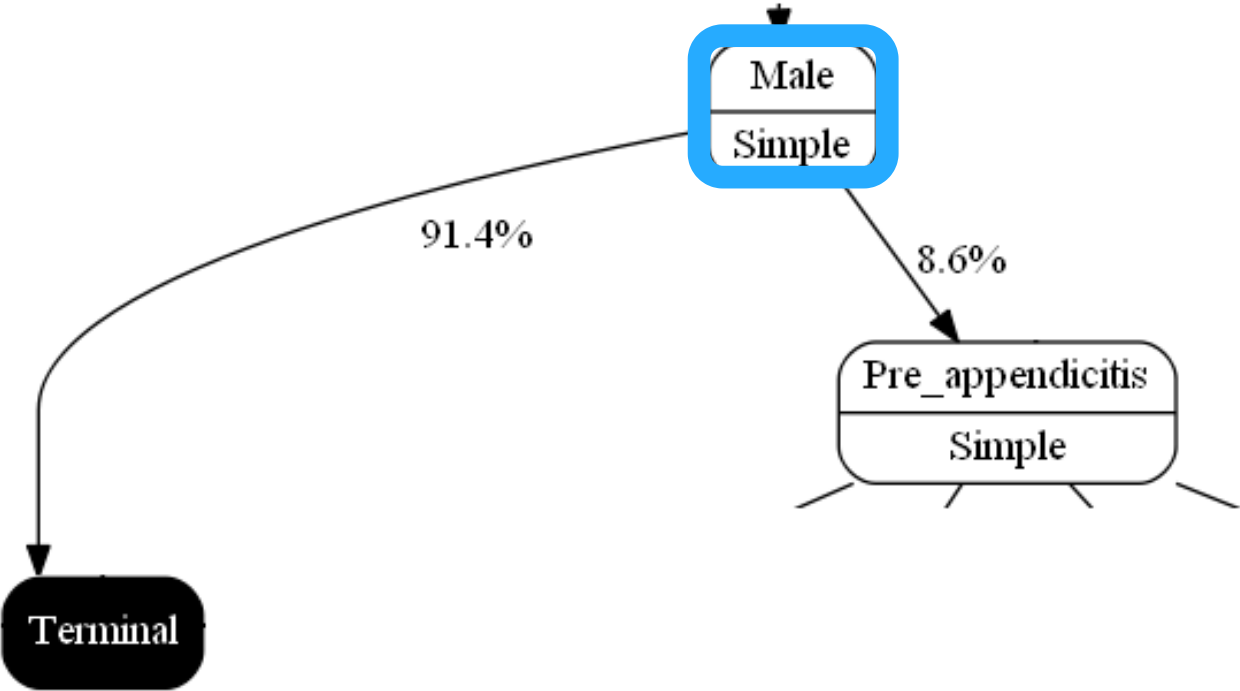
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Current Date of Simulation:
March 25, 1947

Smith292, John949

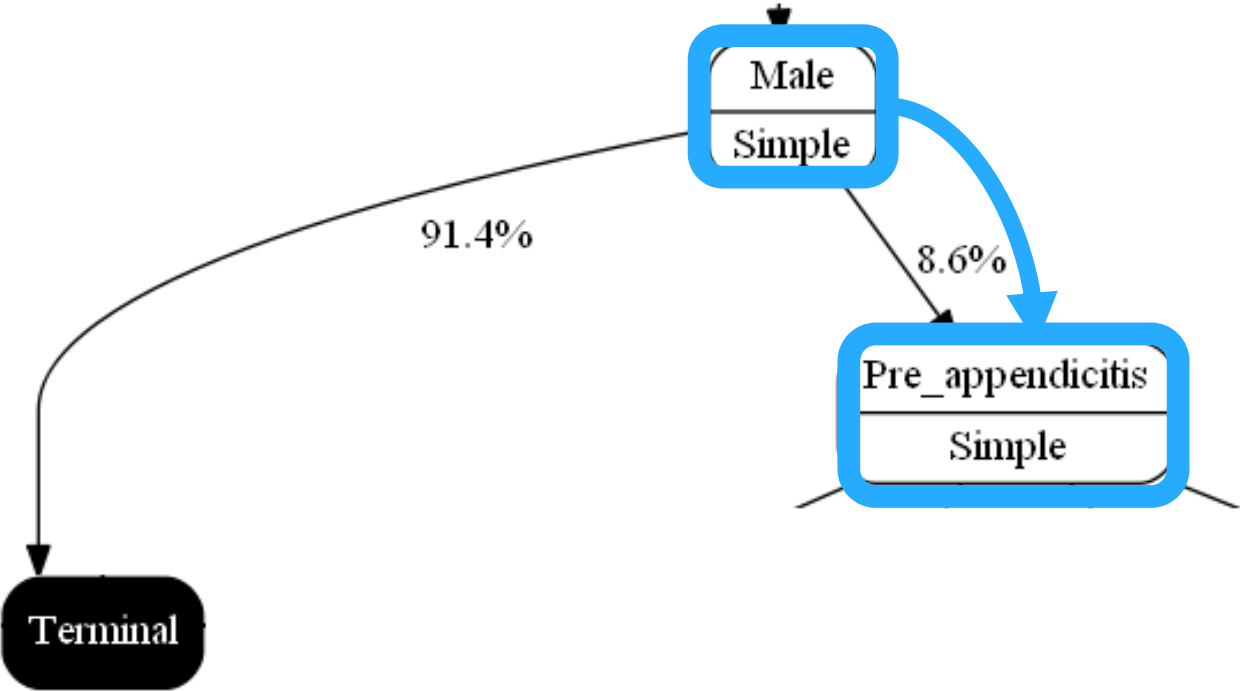
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Conditions:

Procedures:



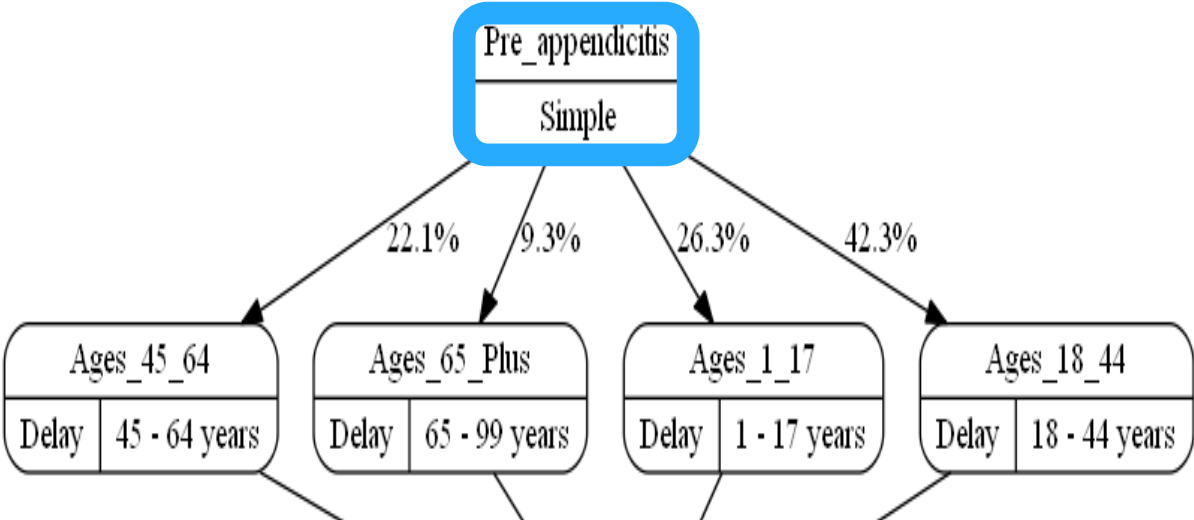
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Current Date of Simulation:
March 25, 1947

Smith292, John949

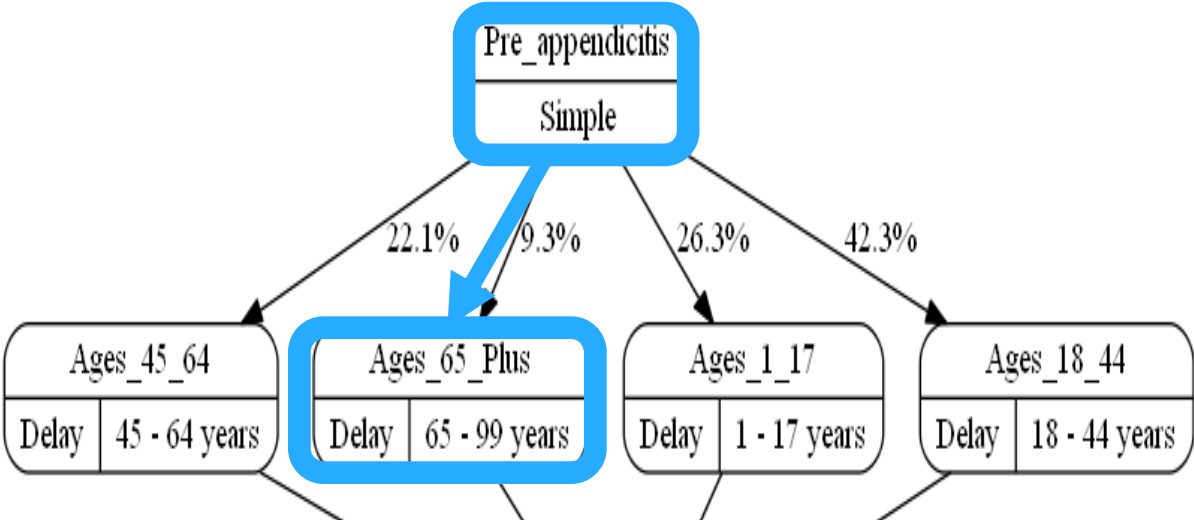
Born: March 25, 1947

Gender: Male

Encounters:

Conditions:

Procedures:



**Current Date of Simulation:
March 25, 1947**

Smith292, John949

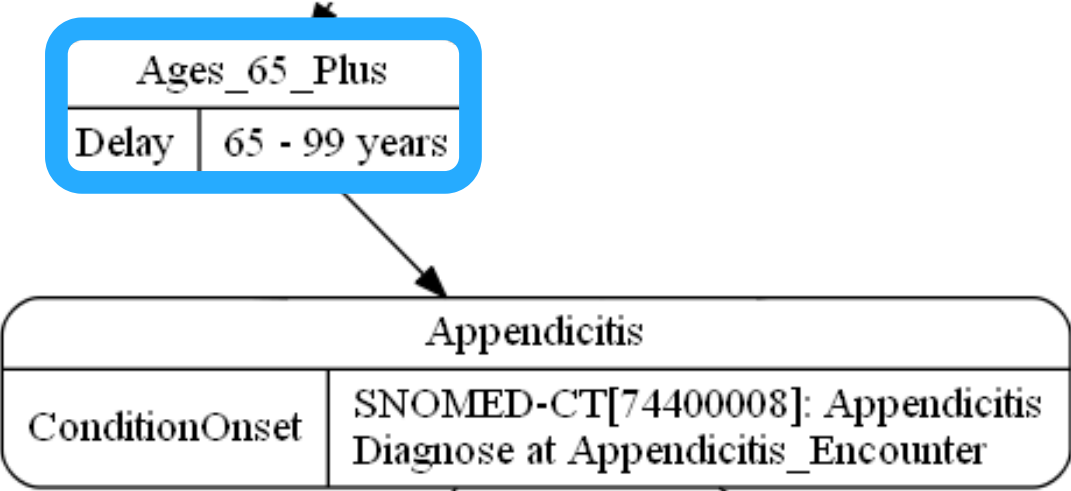
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Gender: Male

Encounters:

Conditions:

Procedures:



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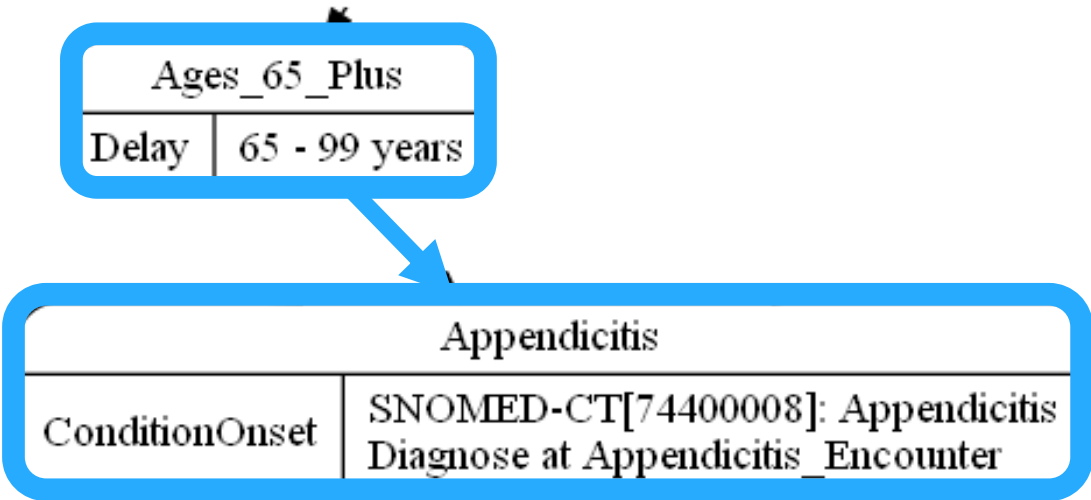
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Encounters:

Conditions:

Procedures:



**Current Date of Simulation:
July 23, 2013**

Smith292, John949

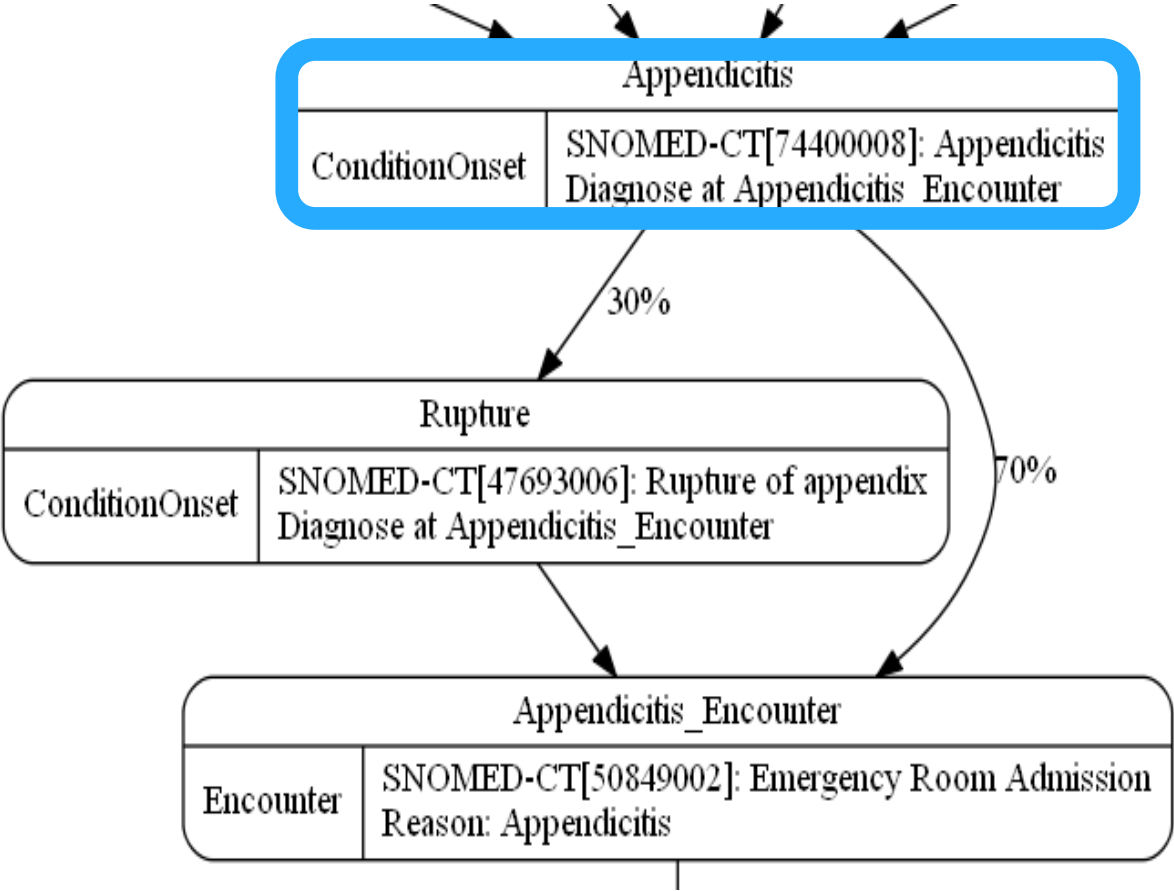
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Conditions:

Procedures:



**Current Date of Simulation:
July 23, 2013**

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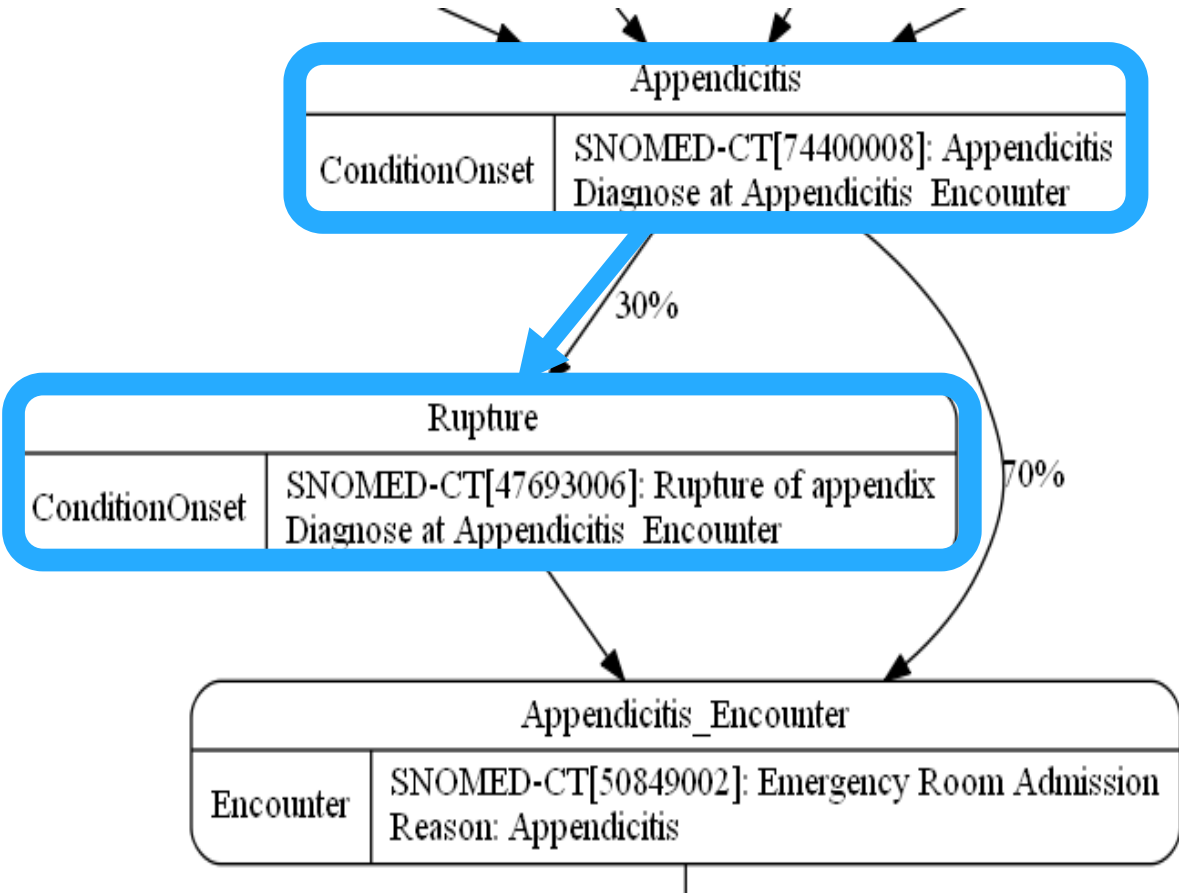
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Gender: Male

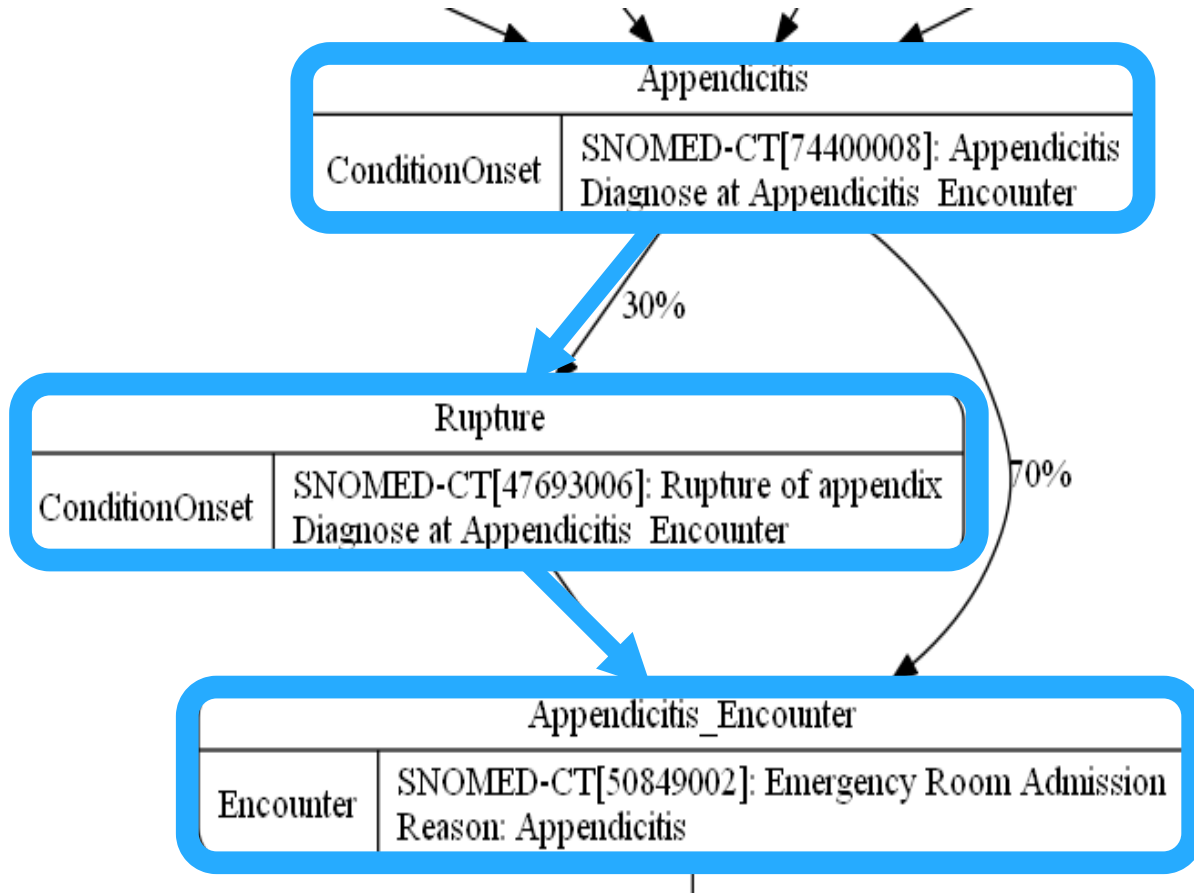
Encounters:

Conditions:

Procedures:



**Current Date of Simulation:
July 23, 2013**



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Gender: Male

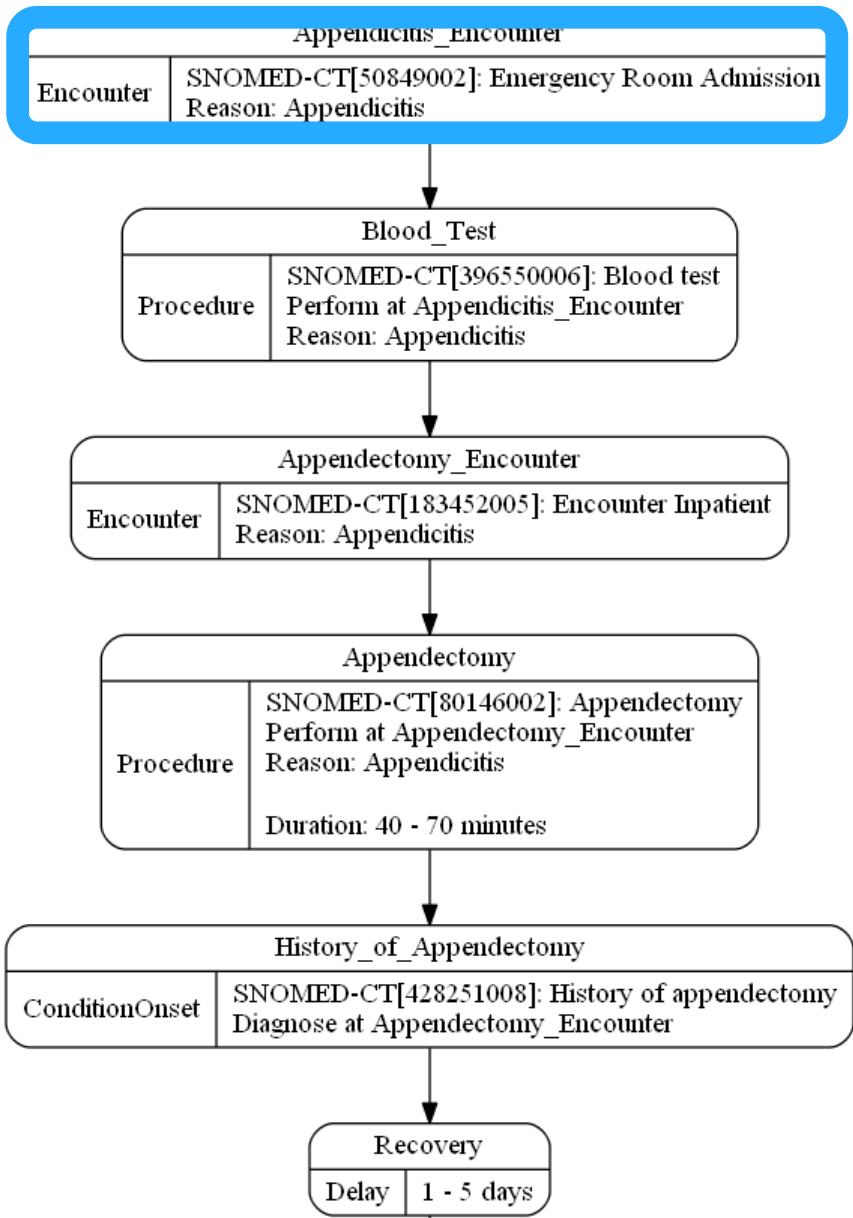
Encounters:

Emergency Room Admission,
July 23, 2013 →

Conditions:

Appendicitis, Diagnosed July 23, 2013
Rupture of appendix, Diagnosed July 23, 2013

Procedures:



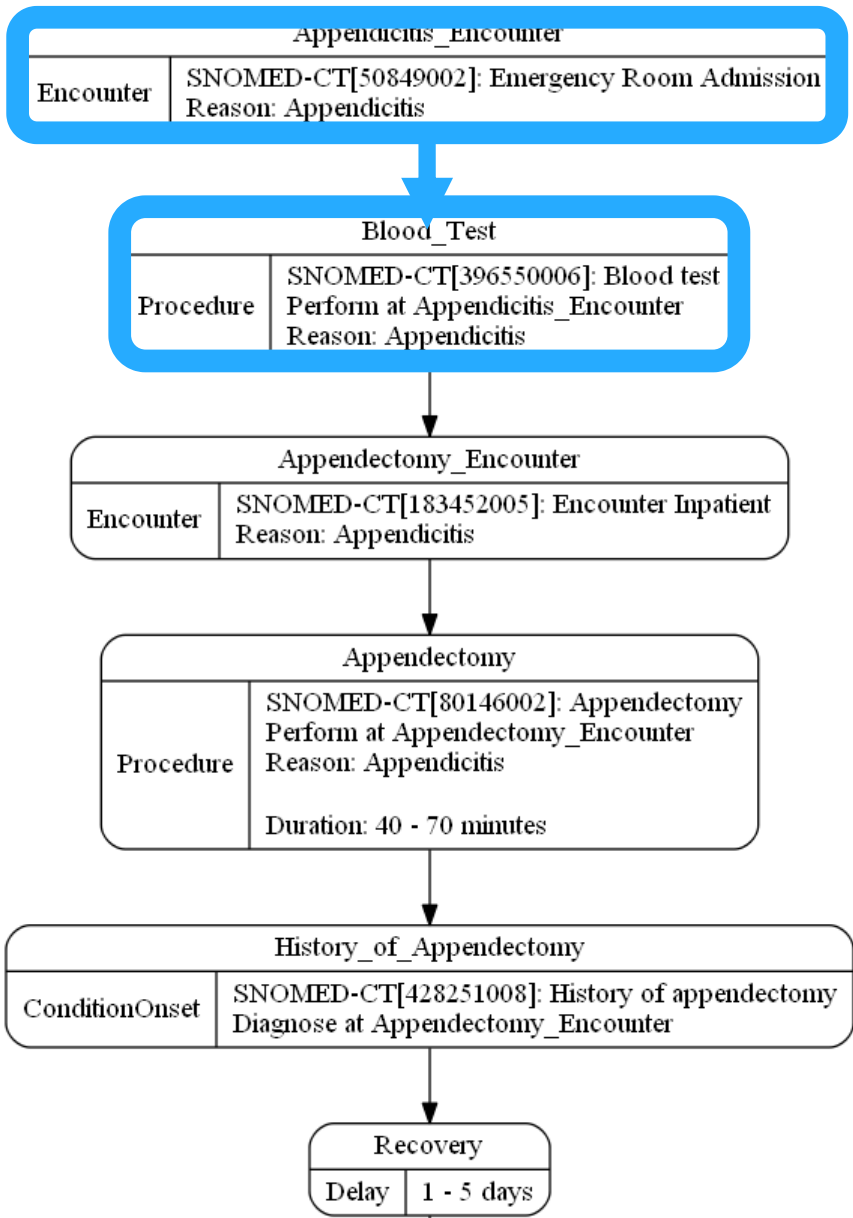
Current Date of Simulation:
July 23, 2013

Smith292, John949
Born: March 25, 1947
Gender: Male

Encounters:
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 July 23, 2013 →

Conditions:
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 Rupture of appendix, Diagnosed July 23, 2013

Procedures:



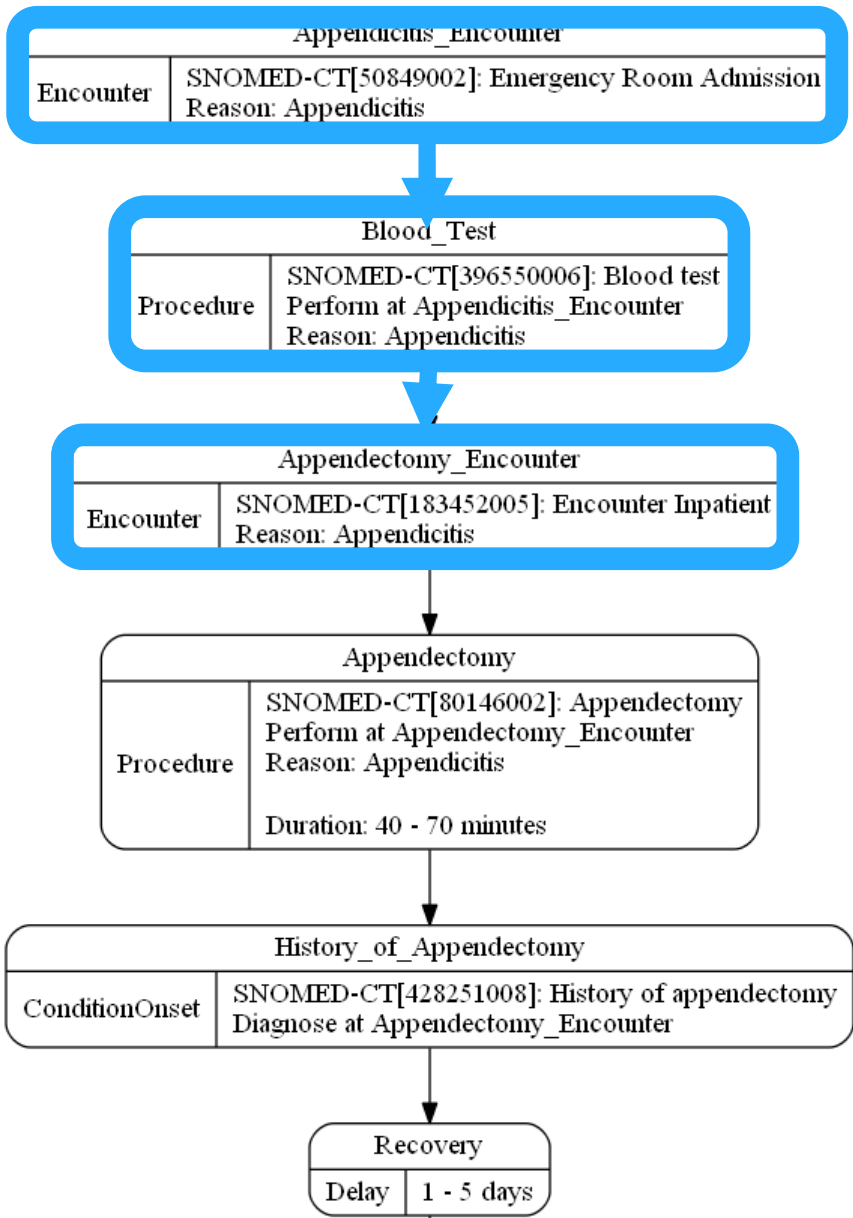
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Gender: Male

Encounters:
 Emergency Room Admission,
 July 23, 2013 →

Conditions:
 Appendicitis, Diagnosed July 23, 2013
 Rupture of appendix, Diagnosed July 23, 2013

Procedures:
 Blood Test, Performed July 23, 2013



Current Date of Simulation:
July 23, 2013

Smith292, John949
Born: March 25, 1947
Gender: Male

Encounters:
 Emergency Room Admission,
 July 23, 2013 → July 23, 2013
 Inpatient Encounter,
 July 23, 2013 →

Conditions:
 Appendicitis, Diagnosed July 23, 2013
 Rupture of appendix, Diagnosed July 23, 2013

Procedures:
 Blood Test, Performed July 23, 2013

Appendicitis_Encounter	
Encounter	SNOMED-CT[50849002]: Emergency Room Admission Reason: Appendicitis

Blood_Test	
Procedure	SNOMED-CT[396550006]: Blood test Perform at Appendicitis_Encounter Reason: Appendicitis

Appendectomy_Encounter	
Encounter	SNOMED-CT[183452005]: Encounter Inpatient Reason: Appendicitis

Appendectomy	
Procedure	SNOMED-CT[80146002]: Appendectomy Perform at Appendectomy_Encounter Reason: Appendicitis Duration: 40 - 70 minutes

History_of_Appendectomy	
ConditionOnset	SNOMED-CT[428251008]: History of appendectomy Diagnose at Appendectomy_Encounter

Recovery	
Delay	1 - 5 days

Current Date of Simulation:
July 23, 2013

Smith292, John949
Born: March 25, 1947
Gender: Male

Encounters:
Emergency Room Admission,
July 23, 2013 → July 23, 2013
Inpatient Encounter,
July 23, 2013 →

Conditions:
Appendicitis, Diagnosed July 23, 2013
Rupture of appendix, Diagnosed July 23, 2013

Procedures:
Blood Test, Performed July 23, 2013
Appendectomy, Performed July 23, 2013

Appendicitis_Encounter	
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Blood_Test	
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Appendectomy_Encounter	
Encounter	SNOMED-CT[183452005]: Encounter Inpatient Reason: Appendicitis

Appendectomy	
Procedure	SNOMED-CT[80146002]: Appendectomy Perform at Appendectomy_Encounter Reason: Appendicitis Duration: 40 - 70 minutes

History_of_Appendectomy	
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July 23, 2013

Smith292, John949

Born: March 25, 1947

Gender: Male

Encounters:

Emergency Room Admission,
July 23, 2013 → July 23, 2013

Inpatient Encounter,
July 23, 2013 →

Conditions:

Appendicitis, Diagnosed July 23, 2013

Rupture of appendix, Diagnosed July 23, 2013

History of appendectomy, Diagnosed July 23 2013

Procedures:

Blood Test, Performed July 23, 2013

Appendectomy, Performed July 23, 2013

Appendicitis_Encounter	
Encounter	SNOMED-CT[50849002]: Emergency Room Admission Reason: Appendicitis

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Gender: Male

Encounters:

Emergency Room Admission,
July 23, 2013 → July 23, 2013

Inpatient Encounter,
July 23, 2013 →

Conditions:

Appendicitis, Diagnosed July 23, 2013

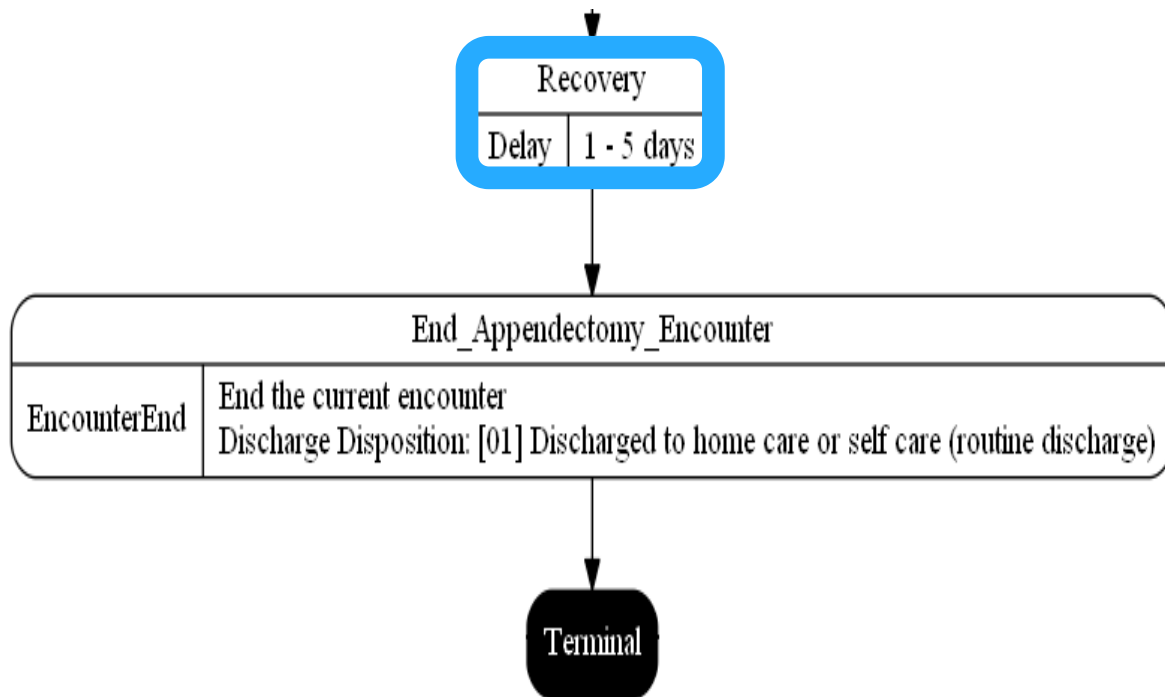
Rupture of appendix, Diagnosed July 23, 2013

History of appendectomy, Diagnosed July 23 2013

Procedures:

Blood Test, Performed July 23, 2013

Appendectomy, Performed July 23, 2013



Current Date of Simulation:
July 23, 2013

Smith292, John949

Born: March 25, 1947

Gender: Male

Encounters:

Emergency Room Admission,
July 23, 2013 → July 23, 2013

Inpatient Encounter,
July 23, 2013 →

Conditions:

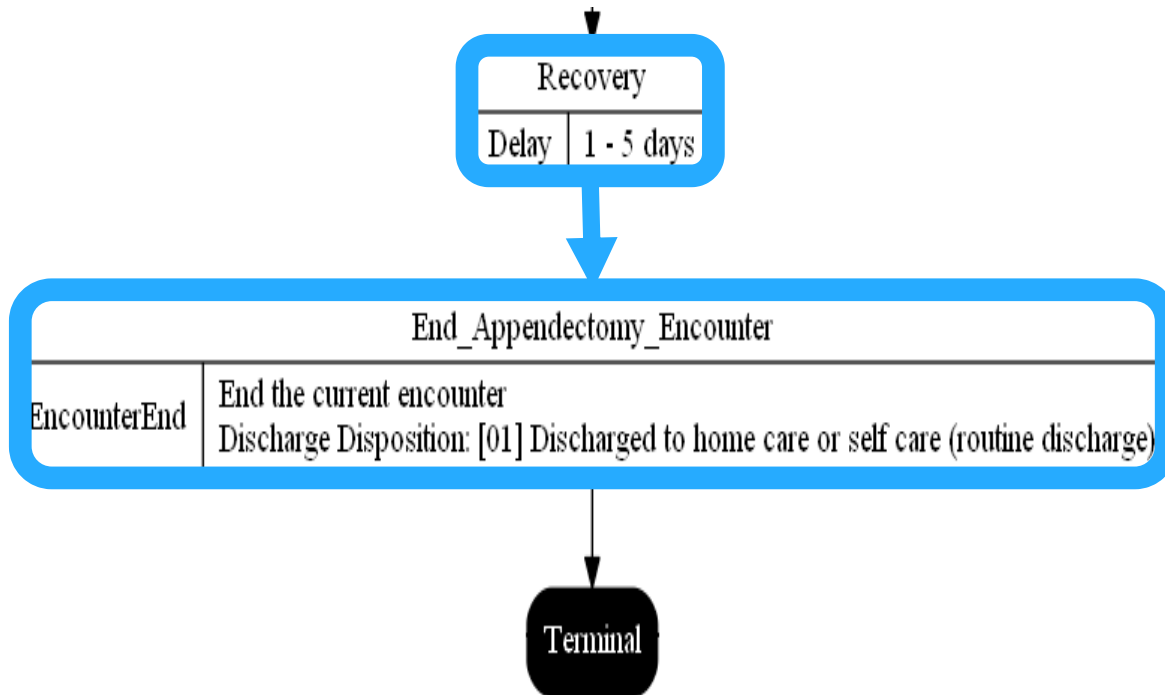
Appendicitis, Diagnosed July 23, 2013

Rupture of appendix, Diagnosed July 23, 2013

History of appendectomy, Diagnosed July 23 2013

Procedures:

Appendectomy, Performed July 23, 2013



Current Date of Simulation:
July 27, 2013

Smith292, John949

Born: March 25, 1947

Gender: Male

Encounters:

Emergency Room Admission,
July 23, 2013 → July 23, 2013

Inpatient Encounter,
July 23, 2013 → **July 27, 2013**

Conditions:

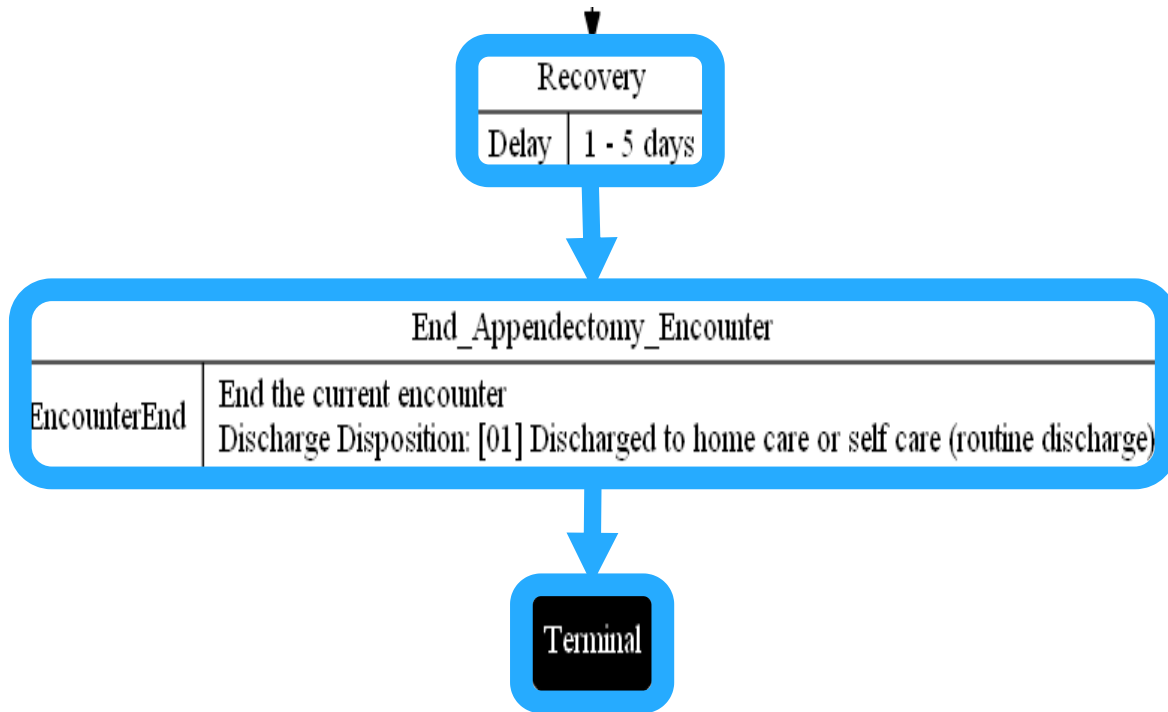
Appendicitis, Diagnosed July 23, 2013

Rupture of appendix, Diagnosed July 23, 2013

History of appendectomy, Diagnosed July 23 2013

Procedures:

Appendectomy, Performed July 23, 2013



Current Date of Simulation:
July 27, 2013

Smith292, John949

Born: March 25, 1947

Gender: Male

Encounters:

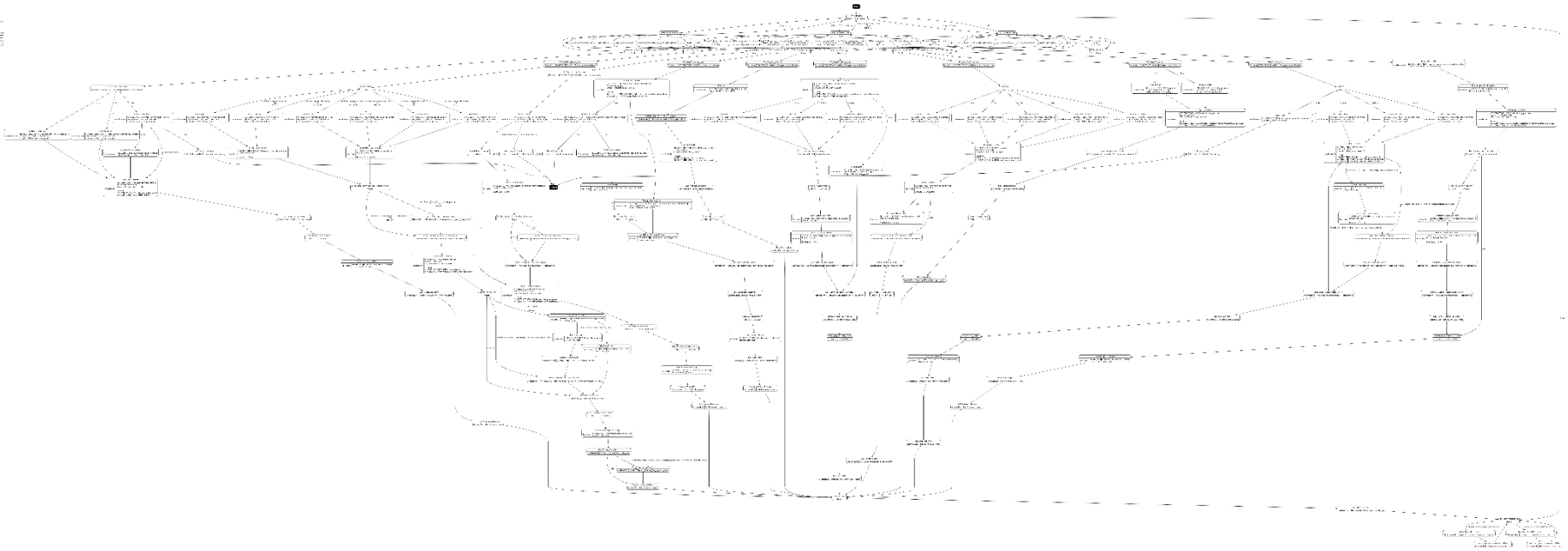
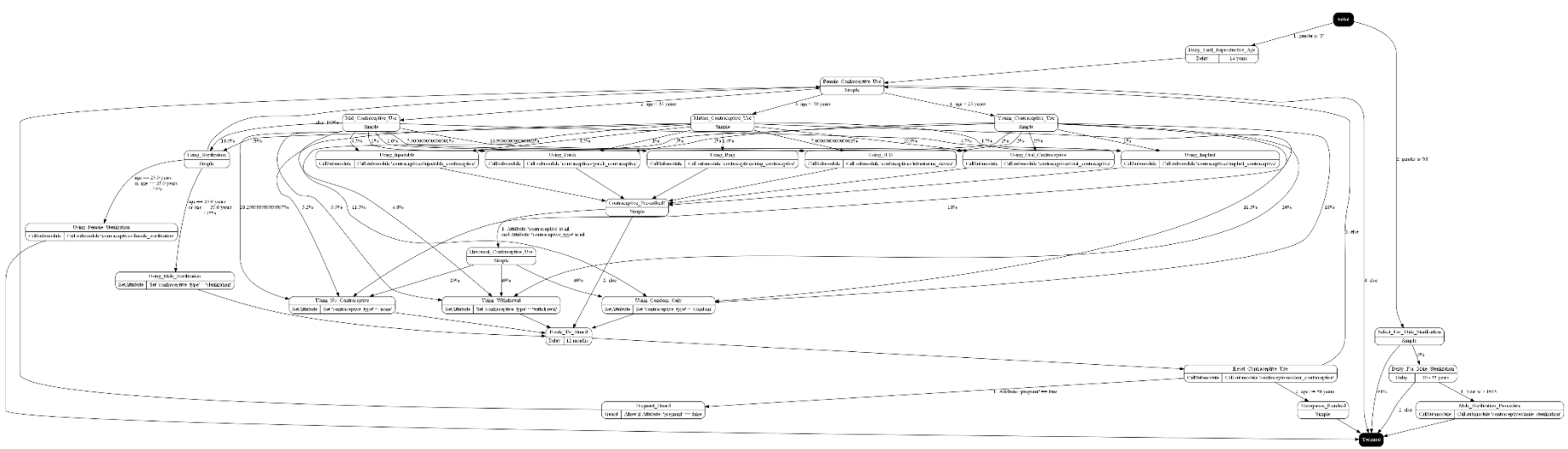
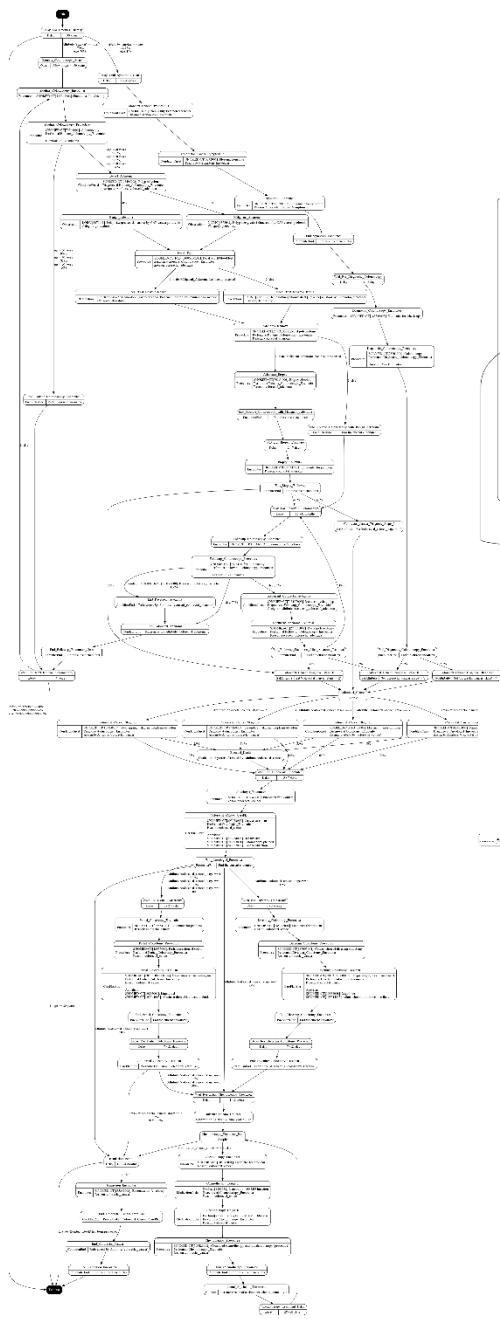
Emergency Room Admission,
July 23, 2013 → July 23, 2013
Inpatient Encounter,
July 23, 2013 → July 27, 2013

Conditions:

Appendicitis, Diagnosed July 23, 2013
Rupture of appendix, Diagnosed July 23, 2013
History of appendectomy, Diagnosed July 23 2013

Procedures:

Appendectomy, Performed July 23, 2013



Export Formats



HL7® C-CDA®



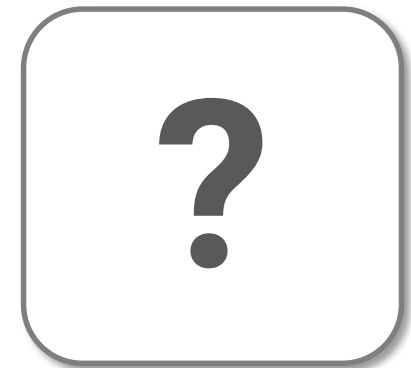
HL7® FHIR®



Human Readable
HTML or Plain Text



CSV



You tell us!

Easy to Set Up – Under an Hour

No Cost, No Restrictions

SyntheticMass

1,000,000 synthetic patients
available for download today
free of cost, free of restrictions

<https://syntheticmass.mitre.org>

Source of Data:

Geographic region:

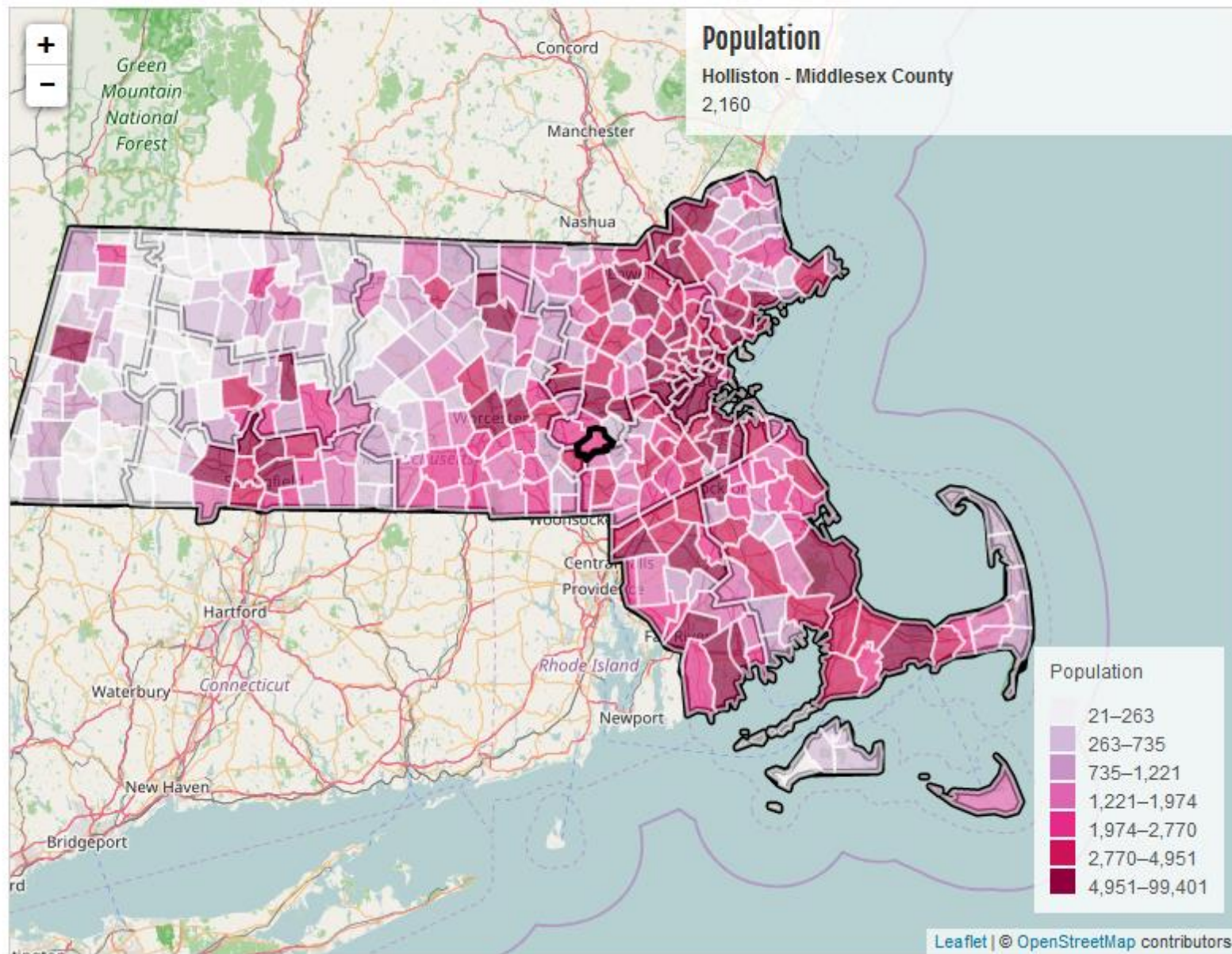
Data Value:

[Zoom map to all](#)

Population

Number of Residents

Region Type	Cities and Towns
Data Set	Synthetic data generated from Synthea
Total Population	1,009,150
Mean	2,875
Max	Boston Cities and Towns: 99,401
Min	Gosnold Cities and Towns: 21



[Sort by Population](#) | [Sort by name](#)

Source of Data: Synthea

Geographic region: Cities and Towns

Data Value: Population

[Zoom map to all](#)

Bedford

× Close

County	Middlesex
Population	2,106
Population Density	154.2 (per mi ²)
Area	14 sq. mi. Zoom
Demographics	
Female Population	50.6% (151 of 351)
Male Population	49.4% (201 of 351)
Diabetes Prevalence	6.2% (313 of 351)
Opioid Addiction Prevalence	0.9% (124 of 351)
Heart Disease Prevalence	4.9% (20 of 351)

Name	Gender	DOB
Terry123, Bessie159	female	03.Jun.1918
Hudson573, Colleen618	female	19.Dec.1921
Herman43, Hettie503	female	25.Apr.1939
O'Reilly259, Aidan944	female	21.Dec.1944
Aufderhar874, Carlee265	female	26.Sep.1951
Skiles93, Julianne73	male	07.May.1952
Kualis486, Darwin648	male	18.Mar.1957
Gorczyan106, Kali960	female	16.Feb.1958

Patient Record

× Close



Family name: **Kualis486**
 Given name: **Darwin648**
 Address: **6057 Stoltenberg Throughway**
 City, State: **Bedford, MA**
 Postal Code: **01730**

[Download Patient Data \(FHIR JSON\)](#) | [Download Patient Data \(CCDA XML\)](#)
[Send Data via Direct Message](#)

Height	187.09 cm	DOB	18.Mar.1957
Weight	128.39 kg	Age	60
Blood Type	n/a	Gender	male
Vision	n/a	Race	White
		Ethnicity	Nonhispanic
		Spoken language	n/a

[Observations](#) **Conditions** [Medications](#) [Allergies](#) [Care Plans](#) [More](#)

Conditions	Date of Onset	Date Resolved
Prediabetes	03.Jan.1991	n/a
Diabetes	04.Nov.1993	n/a
Diabetic retinopathy associated with type II diabetes mellitus (disorder)	03.Dec.1999	n/a
Nonproliferative diabetic retinopathy due to type 2 diabetes mellitus (disorder)	03.Dec.1999	n/a

How are people using Synthea?

Software Development & Integration

HL7-AMIA Datathon: Informatics in the Age of FHIR®, March 2017
HL7 FHIR Connectathon 15, May 2017
PULSE@MassChallenge

Education

Risk-free data for students and researchers in clinical informatics

Data Analysis

Model validation – performing analytics to compare synthetic data to real data
Building tooling & models before moving to real data

Performance Testing

Use Synthea to generate hundreds, thousands, or even millions of synthetic patient records, to test system performance at scale

Join our open source community!

Submit a Pull Request

Report an Issue

Request a Feature

Let us know how you use Synthea!

Contact

- **Dylan Hall, Software Engineer**
- **Jason Walonoski, Project Lead**

dehall@mitre.org

jwalonoski@mitre.org

<https://synthetichealth.github.io/synthea/>



MITRE

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