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In [16]: import requests
import pandas as pd
import matplotlib.pyplot as plt

# this is the server which hosts all the patient data.
# in the real-world this would be an EHR vendor
# this is a open-source server with synthetic data for developers to learn a
FHIR_BASE = "http://hapi.fhir.org/baseR4"
```

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In [17]: # Healthcare applications rarely store all their own data. Instead, they
# exchange information with electronic health record (EHR) systems using
# standards. FHIR (Fast Healthcare Interoperability Resources) is a standard
# based on RESTful web API ideas and allows for retrieving patient informati
# from an EHR AND adding information to an EHR (provided the application has
# authorization)

# In this tutorial, we will walk through how to interact with a public FHIR
# server to get information about a patient.

# We will also create a synthetic patient with clinical information (because
# public servers often don't have the test patients we might need)

# Pretend you are building a new health application for patients which will
# them some health trends and their current medications. The app should be a
# to:
#   - Retrieve health data such as blood pressure, heart rate, and lab resul
#   - Retrieve active medications

# Pull this information back out and display it as tables and charts so pati
# can see trends in their health over time

# By the end of this exercise, you'll have a toy prototype that demonstrates
# a modern health application can connect to a standards-based health data
# source.
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In [18]: # let's query the FHIR server to get information about a patient.
# we'll find up to 5 patients with last name "Smith" (chosen because these
# public servers often use this name)

# Recall that everything in FHIR is a "Resource" (patients, observations, et

resp = requests.get(f"{FHIR_BASE}/Patient", params={"name": "Smith", "_count
patients = resp.json()

for entry in patients.get("entry", []):
    patient = entry["resource"]
    print(patient["id"], patient.get("name"))
```

```
pat2 [{'use': 'official', 'family': 'Smith', 'given': ['John']}]  
593004 [{'family': 'Davidzo', 'given': ['Smith']}]  
594843 [{'family': 'Davidzo', 'given': ['Nilesch']}, {'use': 'official', 'family': 'Smith', 'given': ['Michelle']}]  
597226 [{'use': 'official', 'family': 'Smith', 'given': ['Sean']}]  
597372 [{'family': 'Joe', 'given': ['Smith']}]
```

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In [19]: # we can see that there are 3 patients with this last name. each has a unique ID  
# let's look at "Observations" from the first, limiting to the first 50  
  
patient_id = "pat2" # replace with real ID from above  
resp = requests.get(f"{FHIR_BASE}/Observation", params={"patient": patient_id})  
obs = resp.json()  
  
# and now let's print out all the observations  
obs  
  
# it's a lot! copy into a JSON viewer to look at the structure  
# https://jsonviewer.stack.hu/
```

```
Out[19]: {'resourceType': 'Bundle',
  'id': 'ef4511fa-2493-416f-8090-5439e47c661b',
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  'type': 'searchset',
  'link': [{'relation': 'self',
    'url': 'https://hapi.fhir.org/baseR4/0bservation?_count=50&patient=pat
2'},
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t'}],
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y Automated count'}]},
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px">Resource Observation &quot;o14&quot; </p></div><p><b>status</b>: final
</p><p><b>code</b>: Alanine aminotransferase [Enzymatic activity/volume] in
Serum or Plasma <span style="background: LightGoldenRodYellow; margin: 4px;
border: 1px solid khaki"> (<a href="https://loinc.org/">LOINC</a>#1742-6; <
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a href="https://browser.ihtsdotools.org/">SNOMED CT</a>#34608000)</span></p>
<p><b>subject</b>: <a href="patient-example-b.html">Patient/pat2</a> &quot;
;Duck DONALD&quot;</p><p><b>performer</b>: <a href="organization-example-la
b.html">Organization/1832473e-2fe0-452d-abe9-3cdb9879522f: Acme Laboratory,
Inc</a> &quot;Clinical Lab&quot;</p><p><b>value</b>: 54 U/L</p><p><b>interp
retation</b>: High <span style="background: LightGoldenRodYellow; margin: 4
px; border: 1px solid khaki"> (<a href="http://terminology.hl7.org/5.1.0/Co
deSystem-v3-ObservationInterpretation.html">ObservationInterpretation</a>#
H)</span></p><h3>ReferenceRanges</h3><table class="grid"><tr><td>-</td><td>
<b>Low</b></td><td><b>High</b></td></tr><tr><td>*</td><td>0 U/L</td><td>45
U/L</td></tr></table></div>'},
  'status': 'final',
  'code': {'coding': [{'system': 'http://loinc.org',
    'code': '1742-6',
    'display': 'Alanine aminotransferase [Enzymatic activity/volume] in
Serum or Plasma'}],
    {'system': 'http://snomed.info/sct', 'code': '34608000'}}},
  'subject': {'reference': 'Patient/pat2'},
  'performer': [{'reference': 'Organization/1832473e-2fe0-452d-abe9-3cdb9
879522f',
    'display': 'Acme Laboratory, Inc'}],
  'valueQuantity': {'value': 54, 'unit': 'U/L'},
  'interpretation': [{'coding': [{'system': 'http://terminology.hl7.org/C
odeSystem/v3-ObservationInterpretation',
    'code': 'H'}]}],
  'referenceRange': [{'low': {'value': 0, 'unit': 'U/L'},
    'high': {'value': 45, 'unit': 'U/L'}}],
  'search': {'mode': 'match'}},
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    'id': '44801537',
    'meta': {'versionId': '1',
      'lastUpdated': '2024-07-11T15:44:08.135+00:00',
      'source': '#tYPNjWj0MUuCAKv'},
    'text': {'status': 'generated',
      'div': '<div xmlns="http://www.w3.org/1999/xhtml"><p><b>Generated Narr
ative: Observation</b><a name="o15"> </a></p><div style="display: inline-bl
ock; background-color: #d9e0e7; padding: 6px; margin: 4px; border: 1px soli
d #8da1b4; border-radius: 5px; line-height: 60%"><p style="margin-bottom: 0
px">Resource Observation &quot;o15&quot; </p></div><p><b>status</b>: final
</p><p><b>code</b>: Aspartate aminotransferase [Enzymatic activity/volume]
in Serum or Plasma <span style="background: LightGoldenRodYellow; margin: 4
px; border: 1px solid khaki"> (<a href="https://loinc.org/">LOINC</a>#192
0-8; <a href="https://browser.ihtsdotools.org/">SNOMED CT</a>#45896001)</sp
an></p><p><b>subject</b>: <a href="patient-example-b.html">Patient/pat2</a>
&quot;Duck DONALD&quot;</p><p><b>performer</b>: <a href="organization-examp
le-lab.html">Organization/1832473e-2fe0-452d-abe9-3cdb9879522f: Acme Labora
tory, Inc</a> &quot;Clinical Lab&quot;</p><p><b>value</b>: 30 U/L</p><h3>Re
ferenceRanges</h3><table class="grid"><tr><td>-</td><td><b>Low</b></td><td>
<b>High</b></td></tr><tr><td>*</td><td>0 U/L</td><td>41 U/L</td></tr></tabl
e></div>'},
  'status': 'final',
  'code': {'coding': [{'system': 'http://loinc.org',
    'code': '1920-8',
    'display': 'Aspartate aminotransferase [Enzymatic activity/volume] i
n Serum or Plasma'}],

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{'system': 'http://snomed.info/sct', 'code': '45896001'}}]],
'subject': {'reference': 'Patient/pat2'},
'performer': [{'reference': 'Organization/1832473e-2fe0-452d-abe9-3cdb9
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'display': 'Acme Laboratory, Inc'}],
'valueQuantity': {'value': 30, 'unit': 'U/L'},
'referenceRange': [{'low': {'value': 0, 'unit': 'U/L'},
'high': {'value': 41, 'unit': 'U/L'}}]],
'search': {'mode': 'match'}},
{'fullUrl': 'https://hapi.fhir.org/baseR4/Observation/44801538',
'resource': {'resourceType': 'Observation',
'id': '44801538',
'meta': {'versionId': '1',
'lastUpdated': '2024-07-11T15:44:08.135+00:00',
'source': '#tYPNjWj0MUUsuCAKv'},
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ative: Observation</b><a name="o6"> </a></p><div style="display: inline-blo
ck; background-color: #d9e0e7; padding: 6px; margin: 4px; border: 1px solid
#8da1b4; border-radius: 5px; line-height: 60%"><p style="margin-bottom: 0px
">Resource Observation &quot;o6&quot; </p></div><p><b>status</b>: final</p>
<p><b>code</b>: Glucose [Moles/volume] in Serum or Plasma <span style="back
ground: LightGoldenRodYellow; margin: 4px; border: 1px solid khaki"> (<a hr
ef="https://loinc.org/">LOINC</a>#14749-6; <a href="https://browser.ihtsdot
ools.org/">SNOMED CT</a>#36048009)</span></p><p><b>subject</b>: <a href="pa
tient-example-b.html">Patient/pat2</a> &quot;Duck DONALD&quot;</p><p><b>per
former</b>: <a href="organization-example-lab.html">Organization/1832473e-2
fe0-452d-abe9-3cdb9879522f: Acme Laboratory, Inc</a> &quot;Clinical Lab&quo
t;</p><p><b>value</b>: 7.4 mmol/L</p><h3>ReferenceRanges</h3><table class
="grid"><tr><td>-</td><td><b>Low</b></td><td><b>High</b></td></tr><tr><td>*
</td><td>3.0 mmol/L</td><td>7.7 mmol/L</td></tr></table></div>'},
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'display': 'Glucose [Moles/volume] in Serum or Plasma'}],
'system': 'http://snomed.info/sct', 'code': '36048009'}}]],
'subject': {'reference': 'Patient/pat2'},
'performer': [{'reference': 'Organization/1832473e-2fe0-452d-abe9-3cdb9
879522f',
'display': 'Acme Laboratory, Inc'}],
'valueQuantity': {'value': 7.4, 'unit': 'mmol/L'},
'referenceRange': [{'low': {'value': 3, 'unit': 'mmol/L'},
'high': {'value': 7.7, 'unit': 'mmol/L'}}]],
'search': {'mode': 'match'}},
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'meta': {'versionId': '1',
'lastUpdated': '2024-07-11T15:44:08.135+00:00',
'source': '#tYPNjWj0MUUsuCAKv'},
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ative: Observation</b><a name="o7"> </a></p><div style="display: inline-blo
ck; background-color: #d9e0e7; padding: 6px; margin: 4px; border: 1px solid
#8da1b4; border-radius: 5px; line-height: 60%"><p style="margin-bottom: 0px
">Resource Observation &quot;o7&quot; </p></div><p><b>status</b>: final</p>
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<p><b>code</b>: Urea nitrogen [Moles/volume] in Serum or Plasma <span style
="background: LightGoldenRodYellow; margin: 4px; border: 1px solid khaki">
(<a href="https://loinc.org/">LOINC</a>#14937-7; <a href="https://browser.i
htsdotools.org/">SNOMED CT</a>#273967009)</span></p><p><b>subject</b>: <a h
ref="patient-example-b.html">Patient/pat2</a> &quot;Duck DONALD&quot;</p><p>
<b>performer</b>: <a href="organization-example-lab.html">Organization/183
2473e-2fe0-452d-abe9-3cdb9879522f: Acme Laboratory, Inc</a> &quot;Clinical
Lab&quot;</p><p><b>value</b>: 4.7 mmol/L</p><h3>ReferenceRanges</h3><table
class="grid"><tr><td>-</td><td><b>Low</b></td><td><b>High</b></td></tr><tr>
<td>*</td><td>2.0 mmol/L</td><td>7.0 mmol/L</td></tr></table></div>'>
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  'code': {'coding': [{'system': 'http://loinc.org',
    'code': '14937-7',
    'display': 'Urea nitrogen [Moles/volume] in Serum or Plasma'},
    {'system': 'http://snomed.info/sct', 'code': '273967009'}]},
  'subject': {'reference': 'Patient/pat2'},
  'performer': [{'reference': 'Organization/1832473e-2fe0-452d-abe9-3cdb9
879522f',
    'display': 'Acme Laboratory, Inc'}],
  'valueQuantity': {'value': 4.7, 'unit': 'mmol/L'},
  'referenceRange': [{'low': {'value': 2, 'unit': 'mmol/L'},
    'high': {'value': 7, 'unit': 'mmol/L'}}],
  'search': {'mode': 'match'}},
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    'id': '44801540',
    'meta': {'versionId': '1',
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ative: Observation</b><a name="o8"> </a></p><div style="display: inline-blo
ck; background-color: #d9e0e7; padding: 6px; margin: 4px; border: 1px solid
#8da1b4; border-radius: 5px; line-height: 60%"><p style="margin-bottom: 0px
">Resource Observation &quot;o8&quot;</p></div><p><b>status</b>: final</p>
<p><b>code</b>: Creatinine [Moles/volume] in Serum or Plasma <span style="b
ackground: LightGoldenRodYellow; margin: 4px; border: 1px solid khaki"> (<a
href="https://loinc.org/">LOINC</a>#14682-9; <a href="https://browser.ihtsd
otools.org/">SNOMED CT</a>#70901006)</span></p><p><b>subject</b>: <a href
="patient-example-b.html">Patient/pat2</a> &quot;Duck DONALD&quot;</p><p><b>
performer</b>: <a href="organization-example-lab.html">Organization/183247
3e-2fe0-452d-abe9-3cdb9879522f: Acme Laboratory, Inc</a> &quot;Clinical Lab
&quot;</p><p><b>value</b>: 0.09 mmol/L</p><h3>ReferenceRanges</h3><table cl
ass="grid"><tr><td>-</td><td><b>Low</b></td><td><b>High</b></td></tr><tr><t
d>*</td><td>0.04 mmol/L</td><td>0.11 mmol/L</td></tr></table></div>'>
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        {'system': 'http://snomed.info/sct', 'code': '70901006'}]},
    'subject': {'reference': 'Patient/pat2'},
    'performer': [{'reference': 'Organization/1832473e-2fe0-452d-abe9-3cdb9
879522f',
      'display': 'Acme Laboratory, Inc'}],
    'valueQuantity': {'value': 0.09, 'unit': 'mmol/L'},
    'referenceRange': [{'low': {'value': 0.04, 'unit': 'mmol/L'},
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    'high': {'value': 0.11, 'unit': 'mmol/L'}}}],
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        'id': '44801541',
        'meta': {'versionId': '1',
          'lastUpdated': '2024-07-11T15:44:08.135+00:00',
          'source': '#tYPNjWj0MUsuCAKv'},
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ative: Observation</b><a name="o17"> </a></p><div style="display: inline-bl
ock; background-color: #d9e0e7; padding: 6px; margin: 4px; border: 1px soli
d #8da1b4; border-radius: 5px; line-height: 60%"><p style="margin-bottom: 0
px">Resource Observation &quot;o17&quot; </p></div><p><b>status</b>: final
</p><p><b>code</b>: Calcium [Moles/volume] in Serum or Plasma <span style="
background: LightGoldenRodYellow; margin: 4px; border: 1px solid khaki"> (<
a href="https://loinc.org/">LOINC</a>#2000-8; <a href="https://browser.ihts
dotools.org/">SNOMED CT</a>#71878006)</span></p><p><b>subject</b>: <a href
="patient-example-b.html">Patient/pat2</a> &quot;Duck DONALD&quot;</p><p><b>per
former</b>: <a href="organization-example-lab.html">Organization/183247
3e-2fe0-452d-abe9-3cdb9879522f: Acme Laboratory, Inc</a> &quot;Clinical Lab
&quot;</p><p><b>value</b>: 2.38 mmol/L</p><h3>ReferenceRanges</h3><table cl
ass="grid"><tr><td>-</td><td><b>Low</b></td><td><b>High</b></td></tr><tr><t
d>*</td><td>2.25 mmol/L</td><td>2.65 mmol/L</td></tr></table></div>'},
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879522f',
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ative: Observation</b><a name="o1"> </a></p><div style="display: inline-blo
ck; background-color: #d9e0e7; padding: 6px; margin: 4px; border: 1px solid
#8da1b4; border-radius: 5px; line-height: 60%"><p style="margin-bottom: 0px
">Resource Observation &quot;o1&quot; </p></div><p><b>status</b>: final</p>
<p><b>code</b>: Sodium [Moles/volume] in Serum or Plasma <span style="backg
round: LightGoldenRodYellow; margin: 4px; border: 1px solid khaki"> (<a hre
f="https://loinc.org/">LOINC</a>#2951-2; <a href="https://browser.ihtsdotoo
ls.org/">SNOMED CT</a>#104934005)</span></p><p><b>subject</b>: <a href="pat
ient-example-b.html">Patient/pat2</a> &quot;Duck DONALD&quot;</p><p><b>perf
ormer</b>: <a href="organization-example-lab.html">Organization/1832473e-2f
e0-452d-abe9-3cdb9879522f: Acme Laboratory, Inc</a> &quot;Clinical Lab&quo

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t;</p><p><b>value</b>: 140 mmol/L</p><h3>ReferenceRanges</h3><table class
="grid"><tr><td></td><td><b>Low</b></td><td><b>High</b></td></tr><tr><td>*
</td><td>137 mmol/L</td><td>147 mmol/L</td></tr></table></div>'},
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879522f',
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ative: Observation</b><a name="o2"> </a></p><div style="display: inline-blo
ck; background-color: #d9e0e7; padding: 6px; margin: 4px; border: 1px solid
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">Resource Observation &quot;o2&quot; </p></div><p><b>status</b>: final</p>
<p><b>code</b>: Potassium [Moles/volume] in Serum or Plasma <span style="ba
ckground: LightGoldenRodYellow; margin: 4px; border: 1px solid khaki"> (<a
href="https://loinc.org/">LOINC</a>#2823-3; <a href="https://browser.ihtsdo
tools.org/">SNOMED CT</a>#59573005)</span></p><p><b>subject</b>: <a href="p
atient-example-b.html">Patient/pat2</a> &quot;Duck DONALD&quot;</p><p><b>pe
rformer</b>: <a href="organization-example-lab.html">Organization/1832473
e-2fe0-452d-abe9-3cdb9879522f: Acme Laboratory, Inc</a> &quot;Clinical Lab&
quot;</p><p><b>value</b>: 4.2 mmol/L</p><h3>ReferenceRanges</h3><table clas
s="grid"><tr><td></td><td><b>Low</b></td><td><b>High</b></td></tr><tr><td>
*</td><td>3.5 mmol/L</td><td>5.0 mmol/L</td></tr></table></div>'},
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  'subject': {'reference': 'Patient/pat2'},
  'performer': [{'reference': 'Organization/1832473e-2fe0-452d-abe9-3cdb9
879522f',
    'display': 'Acme Laboratory, Inc'}]},
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  'referenceRange': [{'low': {'value': 3.5, 'unit': 'mmol/L'},
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      'code': {'coding': [{'system': 'http://loinc.org',
        'code': '2075-0',
        'display': 'Chloride [Moles/volume] in Serum or Plasma'},
        {'system': 'http://snomed.info/sct', 'code': '46511006'}]},
      'subject': {'reference': 'Patient/pat2'},
      'performer': [{'reference': 'Organization/1832473e-2fe0-452d-abe9-3cdb9879522f',
        'display': 'Acme Laboratory, Inc'}],
      'valueQuantity': {'value': 105, 'unit': 'mmol/L'},
      'referenceRange': [{'low': {'value': 96, 'unit': 'mmol/L'},
        'high': {'value': 109, 'unit': 'mmol/L'}}],
      'search': {'mode': 'match'}},
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          'lastUpdated': '2024-07-11T15:44:08.135+00:00',
          'source': '#tYPNjWj0MUSuCAKv'},
        'text': {'status': 'generated',
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          'status': 'final',
          'code': {'coding': [{'system': 'http://loinc.org',
            'code': '1963-8',
            'display': 'Bicarbonate [Moles/volume] in Serum'}],
        }

```

```
{'system': 'http://snomed.info/sct', 'code': '88645003'}}]],
'subject': {'reference': 'Patient/pat2'},
'performer': [{'reference': 'Organization/1832473e-2fe0-452d-abe9-3cdb9
879522f',
'display': 'Acme Laboratory, Inc'}],
'valueQuantity': {'value': 26, 'unit': 'mmol/L'},
'referenceRange': [{'low': {'value': 25, 'unit': 'mmol/L'},
'high': {'value': 33, 'unit': 'mmol/L'}}]],
'search': {'mode': 'match'}},
{'fullUrl': 'https://hapi.fhir.org/baseR4/Observation/44801546',
'resource': {'resourceType': 'Observation',
'id': '44801546',
'meta': {'versionId': '1',
'lastUpdated': '2024-07-11T15:51:37.783+00:00',
'source': '#kZ3KAReIzyBIPCpk'},
'text': {'status': 'generated',
'div': '<div xmlns="http://www.w3.org/1999/xhtml"><p><b>Generated Narr
ative: Observation</b><a name="o14"> </a></p><div style="display: inline-bl
ock; background-color: #d9e0e7; padding: 6px; margin: 4px; border: 1px soli
d #8da1b4; border-radius: 5px; line-height: 60%"><p style="margin-bottom: 0
px">Resource Observation &quot;o14&quot; </p></div><p><b>status</b>: final
</p><p><b>code</b>: Alanine aminotransferase [Enzymatic activity/volume] in
Serum or Plasma <span style="background: LightGoldenRodYellow; margin: 4px;
border: 1px solid khaki"> (<a href="https://loinc.org/">LOINC</a>#1742-6; <
a href="https://browser.ihtsdotools.org/">SNOMED CT</a>#34608000)</span></p>
<p><b>subject</b>: <a href="patient-example-b.html">Patient/pat2</a> &quot;
;Duck DONALD&quot;</p><p><b>performer</b>: <a href="organization-example-la
b.html">Organization/1832473e-2fe0-452d-abe9-3cdb9879522f: Acme Laboratory,
Inc</a> &quot;Clinical Lab&quot;</p><p><b>value</b>: 54 U/L</p><p><b>interp
retation</b>: High <span style="background: LightGoldenRodYellow; margin: 4
px; border: 1px solid khaki"> (<a href="http://terminology.hl7.org/5.1.0/Co
deSystem-v3-ObservationInterpretation.html">ObservationInterpretation</a>#
H)</span></p><h3>ReferenceRanges</h3><table class="grid"><tr><td>-</td><td>
<b>Low</b></td><td><b>High</b></td></tr><tr><td>*</td><td>0 U/L</td><td>45
U/L</td></tr></table></div>'},
'status': 'final',
'code': {'coding': [{'system': 'http://loinc.org',
'code': '1742-6',
'display': 'Alanine aminotransferase [Enzymatic activity/volume] in
Serum or Plasma'}],
'system': 'http://snomed.info/sct', 'code': '34608000'}}]],
'subject': {'reference': 'Patient/pat2'},
'performer': [{'reference': 'Organization/1832473e-2fe0-452d-abe9-3cdb9
879522f',
'display': 'Acme Laboratory, Inc'}],
'valueQuantity': {'value': 54, 'unit': 'U/L'},
'interpretation': [{'coding': [{'system': 'http://terminology.hl7.org/C
odeSystem/v3-ObservationInterpretation',
'code': 'H'}}]],
'referenceRange': [{'low': {'value': 0, 'unit': 'U/L'},
'high': {'value': 45, 'unit': 'U/L'}}]],
'search': {'mode': 'match'}},
{'fullUrl': 'https://hapi.fhir.org/baseR4/Observation/44801547',
'resource': {'resourceType': 'Observation',
'id': '44801547',
'meta': {'versionId': '1',
```

```

    'lastUpdated': '2024-07-11T15:51:37.783+00:00',
    'source': '#kZ3KAReIzyBIPCpk'},
    'text': {'status': 'generated',
      'div': '<div xmlns="http://www.w3.org/1999/xhtml"><p><b>Generated Narr
ative: Observation</b><a name="o15"> </a></p><div style="display: inline-bl
ock; background-color: #d9e0e7; padding: 6px; margin: 4px; border: 1px soli
d #8da1b4; border-radius: 5px; line-height: 60%"><p style="margin-bottom: 0
px">Resource Observation &quot;o15&quot; </p></div><p><b>status</b>: final
</p><p><b>code</b>: Aspartate aminotransferase [Enzymatic activity/volume]
in Serum or Plasma <span style="background: LightGoldenRodYellow; margin: 4
px; border: 1px solid khaki"> (<a href="https://loinc.org/">LOINC</a>#192
0-8; <a href="https://browser.ihtsdotools.org/">SNOMED CT</a>#45896001)</sp
an></p><p><b>subject</b>: <a href="patient-example-b.html">Patient/pat2</a>
&quot;Duck DONALD&quot;</p><p><b>performer</b>: <a href="organization-examp
le-lab.html">Organization/1832473e-2fe0-452d-abe9-3cdb9879522f: Acme Labora
tory, Inc</a> &quot;Clinical Lab&quot;</p><p><b>value</b>: 30 U/L</p><h3>Re
ferenceRanges</h3><table class="grid"><tr><td>-</td><td><b>Low</b></td><td>
<b>High</b></td></tr><tr><td>*</td><td>0 U/L</td><td>41 U/L</td></tr></tabl
e></div>'},
    'status': 'final',
    'code': {'coding': [{'system': 'http://loinc.org',
      'code': '1920-8',
      'display': 'Aspartate aminotransferase [Enzymatic activity/volume] i
n Serum or Plasma'}],
      'system': 'http://snomed.info/sct', 'code': '45896001'}]},
    'subject': {'reference': 'Patient/pat2'},
    'performer': [{'reference': 'Organization/1832473e-2fe0-452d-abe9-3cdb9
879522f',
      'display': 'Acme Laboratory, Inc'}],
    'valueQuantity': {'value': 30, 'unit': 'U/L'},
    'referenceRange': [{'low': {'value': 0, 'unit': 'U/L'},
      'high': {'value': 41, 'unit': 'U/L'}}],
    'search': {'mode': 'match'}},
    {'fullUrl': 'https://hapi.fhir.org/baseR4/Observation/44801548',
      'resource': {'resourceType': 'Observation',
        'id': '44801548',
        'meta': {'versionId': '1',
          'lastUpdated': '2024-07-11T15:51:37.783+00:00',
          'source': '#kZ3KAReIzyBIPCpk'},
          'text': {'status': 'generated',
            'div': '<div xmlns="http://www.w3.org/1999/xhtml"><p><b>Generated Narr
ative: Observation</b><a name="o6"> </a></p><div style="display: inline-blo
ck; background-color: #d9e0e7; padding: 6px; margin: 4px; border: 1px solid
#8da1b4; border-radius: 5px; line-height: 60%"><p style="margin-bottom: 0px
">Resource Observation &quot;o6&quot; </p></div><p><b>status</b>: final</p>
<p><b>code</b>: Glucose [Moles/volume] in Serum or Plasma <span style="back
ground: LightGoldenRodYellow; margin: 4px; border: 1px solid khaki"> (<a hr
ef="https://loinc.org/">LOINC</a>#14749-6; <a href="https://browser.ihtsdot
ools.org/">SNOMED CT</a>#36048009)</span></p><p><b>subject</b>: <a href="pa
tient-example-b.html">Patient/pat2</a> &quot;Duck DONALD&quot;</p><p><b>per
former</b>: <a href="organization-example-lab.html">Organization/1832473e-2
fe0-452d-abe9-3cdb9879522f: Acme Laboratory, Inc</a> &quot;Clinical Lab&quo
t;</p><p><b>value</b>: 7.4 mmol/L</p><h3>ReferenceRanges</h3><table class
="grid"><tr><td>-</td><td><b>Low</b></td><td><b>High</b></td></tr><tr><td>*</td>
<td>3.0 mmol/L</td><td>7.7 mmol/L</td></tr></table></div>'},
          'status': 'final',

```

```

'code': {'coding': [{'system': 'http://loinc.org',
  'code': '14749-6',
  'display': 'Glucose [Moles/volume] in Serum or Plasma'}],
  {'system': 'http://snomed.info/sct', 'code': '36048009'}}],
'subject': {'reference': 'Patient/pat2'},
'performer': [{'reference': 'Organization/1832473e-2fe0-452d-abe9-3cdb9
879522f',
  'display': 'Acme Laboratory, Inc'}],
'valueQuantity': {'value': 7.4, 'unit': 'mmol/L'},
'referenceRange': [{'low': {'value': 3, 'unit': 'mmol/L'},
  'high': {'value': 7.7, 'unit': 'mmol/L'}}}],
'search': {'mode': 'match'}},
{'fullUrl': 'https://hapi.fhir.org/baseR4/Observation/44801549',
'resource': {'resourceType': 'Observation',
'id': '44801549',
'meta': {'versionId': '1',
'lastUpdated': '2024-07-11T15:51:37.783+00:00',
'source': '#kZ3KAReIzyBIPCpk'},
'text': {'status': 'generated',
'div': '<div xmlns="http://www.w3.org/1999/xhtml"><p><b>Generated Narr
ative: Observation</b><a name="o7"> </a></p><div style="display: inline-blo
ck; background-color: #d9e0e7; padding: 6px; margin: 4px; border: 1px solid
#8da1b4; border-radius: 5px; line-height: 60%"><p style="margin-bottom: 0px
">Resource Observation &quot;o7&quot; </p></div><p><b>status</b>: final</p>
<p><b>code</b>: Urea nitrogen [Moles/volume] in Serum or Plasma <span style
="background: LightGoldenRodYellow; margin: 4px; border: 1px solid khaki">
(<a href="https://loinc.org/">LOINC</a>#14937-7; <a href="https://browser.i
htsdotools.org/">SNOMED CT</a>#273967009)</span></p><p><b>subject</b>: <a h
ref="patient-example-b.html">Patient/pat2</a> &quot;Duck DONALD&quot;</p><p>
<b>performer</b>: <a href="organization-example-lab.html">Organization/183
2473e-2fe0-452d-abe9-3cdb9879522f: Acme Laboratory, Inc</a> &quot;Clinical
Lab&quot;</p><p><b>value</b>: 4.7 mmol/L</p><h3>ReferenceRanges</h3><table
class="grid"><tr><td>-</td><td><b>Low</b></td><td><b>High</b></td></tr><tr>
<td>*</td><td>2.0 mmol/L</td><td>7.0 mmol/L</td></tr></table></div>'},
'status': 'final',
'code': {'coding': [{'system': 'http://loinc.org',
  'code': '14937-7',
  'display': 'Urea nitrogen [Moles/volume] in Serum or Plasma'}],
  {'system': 'http://snomed.info/sct', 'code': '273967009'}}],
'subject': {'reference': 'Patient/pat2'},
'performer': [{'reference': 'Organization/1832473e-2fe0-452d-abe9-3cdb9
879522f',
  'display': 'Acme Laboratory, Inc'}],
'valueQuantity': {'value': 4.7, 'unit': 'mmol/L'},
'referenceRange': [{'low': {'value': 2, 'unit': 'mmol/L'},
  'high': {'value': 7, 'unit': 'mmol/L'}}}],
'search': {'mode': 'match'}}}]

```

In [20]: *# let's write some code to unpack this. the results come back as a bundle and
can use our json viewer to see that part of this is a list of resources
in each resource we can find the lab names and values!*

```
observations = []
```

```
for entry in obs.get("entry", []):
    resource = entry["resource"]
```

```

if resource.get("code", {}).get("coding"):
    code = resource.get("code", {}).get("coding")[0].get("display")
    value = resource.get("valueQuantity", {}).get("value")
    unit = resource.get("valueQuantity", {}).get("unit")
    time = resource.get("effectiveDateTime")
else:
    print("Skipping entry due to missing 'coding' information.")

if value:
    observations.append({"code": code, "value": value, "unit": unit, "ti

df = pd.DataFrame(observations)
print(df.head())

```

Skipping entry due to missing 'coding' information.

		code	value	unit	time
0	Cholesterol [Moles/volume] in Serum or Plasma		6.3	mmol/L	None
1	Hemoglobin [Mass/volume] in Blood		176.0	g/L	None
2	Erythrocytes [# /volume] in Blood by Automated ...		5.9	x10*12/L	None
3	Hematocrit [Volume Fraction] of Blood by Autom...		55.0	%	None
4	Erythrocyte mean corpuscular volume [Entitic v...		99.0	fL	None

In [21]: *# as you can see this is a random collection of labs... for our app we need
detail.*

```

# let's create our own patient now so we have control over the data
# we are allowed to do this because it is a public endpoint
# this patient will be purged at some interval

```

In [22]: *# this makes a fake new patient*
if everything goes well, we'll get a 201 response and an ID

```

new_patients = [
    {
        "resourceType": "Patient",
        "name": [{"use": "official", "family": "Doe", "given": ["Jane"]}],
        "gender": "female",
        "birthDate": "1980-05-01"
    },
    {
        'resourceType': 'Patient',
        'name': [{'use': 'official', 'family': 'Smith', 'given': ['Martina']
        'gender': 'female',
        'birthDate': '2003-12-05'
    }
]

for patient in new_patients:
    resp = requests.post(f"{FHIR_BASE}/Patient", json=patient)
    print(resp.status_code, resp.json())
    patient_id = resp.json()["id"]
    print("New Patient ID:", patient_id)

```

```
201 {'resourceType': 'Patient', 'id': '49233411', 'meta': {'versionId': '1',
'lastUpdated': '2025-09-15T04:33:34.917+00:00', 'source': '#qcnXJZvxkLgoJa1
U'}, 'text': {'status': 'generated', 'div': '<div xmlns="http://www.w3.org/1
999/xhtml"><div class="hapiHeaderText">Jane <b>DOE </b></div><table class="h
apiPropertyTable"><tbody><tr><td>Date of birth</td><td><span>01 May 1980</sp
an></td></tr></tbody></table></div>'}, 'name': [{'use': 'official', 'family'
: 'Doe', 'given': ['Jane']}], 'gender': 'female', 'birthDate': '1980-05-01'}
New Patient ID: 49233411
```

```
201 {'resourceType': 'Patient', 'id': '49233412', 'meta': {'versionId': '1',
'lastUpdated': '2025-09-15T04:33:35.917+00:00', 'source': '#MwQFEW7Zk87kmU
l'}, 'text': {'status': 'generated', 'div': '<div xmlns="http://www.w3.org/1
999/xhtml"><div class="hapiHeaderText">Martina <b>SMITH </b></div><table cla
ss="hapiPropertyTable"><tbody><tr><td>Date of birth</td><td><span>05 Decembe
r 2003</span></td></tr></tbody></table></div>'}, 'name': [{'use': 'official'
, 'family': 'Smith', 'given': ['Martina']}], 'gender': 'female', 'birthDate'
: '2003-12-05'}
New Patient ID: 49233412
```

```
In [23]: patient_id = resp.json()["id"]
print("New Patient ID:", patient_id)
```

New Patient ID: 49233412

```
In [24]: # let's add a bunch of random data, one set of observations per day

from random import randint, gauss
from datetime import datetime, timedelta

base_date = datetime(2025, 8, 1)

observations = []
for i in range(5): # 5 days
    dt = (base_date + timedelta(days=i)).isoformat() + "Z"

    observations += [
        {
            "resourceType": "Observation",
            "status": "final",
            "category": [{"coding": [{"system": "http://terminology.hl7.org/
                                "code": "vital-signs"}]}],
            "code": {"text": "Systolic Blood Pressure"},
            "subject": {"reference": f"Patient/{patient_id}"},
            "effectiveDateTime": dt,
            "valueQuantity": {"value": randint(110, 135), "unit": "mmHg"}
        },
        {
            "resourceType": "Observation",
            "status": "final",
            "category": [{"coding": [{"system": "http://terminology.hl7.org/
                                "code": "vital-signs"}]}],
            "code": {"text": "Diastolic Blood Pressure"},
            "subject": {"reference": f"Patient/{patient_id}"},
            "effectiveDateTime": dt,
            "valueQuantity": {"value": randint(70, 90), "unit": "mmHg"}
        },
        {
            "resourceType": "Observation",
```

```

        "status": "final",
        "category": [{"coding": [{"system": "http://terminology.hl7.org/
                                "code": "vital-signs"}]}],
        "code": {"text": "Heart rate"},
        "subject": {"reference": f"Patient/{patient_id}"},
        "effectiveDateTime": dt,
        "valueQuantity": {"value": randint(65, 90), "unit": "beats/min"}
    },
    {
        "resourceType": "Observation",
        "status": "final",
        "category": [{"coding": [{"system": "http://terminology.hl7.org/
                                "code": "laboratory"}]}],
        "code": {"text": "Glucose"},
        "subject": {"reference": f"Patient/{patient_id}"},
        "effectiveDateTime": dt,
        "valueQuantity": {"value": round(gauss(95, 10), 1), "unit": "mg/
    }
]

# POST them
for obs in observations:
    r = requests.post(f"{FHIR_BASE}/Observation", json=obs, params={"patient": patient_id})
    print("Obs:", r.status_code, r.json().get("id"))

```

```

Obs: 201 49233413
Obs: 201 49233414
Obs: 201 49233415
Obs: 201 49233416
Obs: 201 49233417
Obs: 201 49233418
Obs: 201 49233419
Obs: 201 49233420
Obs: 201 49233421
Obs: 201 49233422
Obs: 201 49233423
Obs: 201 49233424
Obs: 201 49233425
Obs: 201 49233426
Obs: 201 49233427
Obs: 201 49233428
Obs: 201 49233429
Obs: 201 49233430
Obs: 201 49233431
Obs: 201 49233432

```

```

In [25]: # Query observations
obs_resp = requests.get(f"{FHIR_BASE}/Observation", params={"patient": patient_id})
print(len(obs_resp.json().get("entry", [])), "observations found")
print(patient_id)

```

```

20 observations found
49233412

```

```

In [26]: observations = []
for entry in obs_resp.json().get("entry", []):
    resource = entry["resource"]

```

```

code = resource.get("code", {}).get("text")
value = resource.get("valueQuantity", {}).get("value")
unit = resource.get("valueQuantity", {}).get("unit")
time = resource.get("effectiveDateTime")
if value:
    observations.append({"code": code, "value": value, "unit": unit, "ti

df = pd.DataFrame(observations)
print(df)

```

		code	value	unit	time
0	Systolic Blood Pressure	115.0	mmHg	2025-08-01T00:00:00Z	
1	Diastolic Blood Pressure	83.0	mmHg	2025-08-01T00:00:00Z	
2	Heart rate	82.0	beats/min	2025-08-01T00:00:00Z	
3	Glucose	109.1	mg/dL	2025-08-01T00:00:00Z	
4	Systolic Blood Pressure	115.0	mmHg	2025-08-02T00:00:00Z	
5	Diastolic Blood Pressure	73.0	mmHg	2025-08-02T00:00:00Z	
6	Heart rate	89.0	beats/min	2025-08-02T00:00:00Z	
7	Glucose	73.5	mg/dL	2025-08-02T00:00:00Z	
8	Systolic Blood Pressure	118.0	mmHg	2025-08-03T00:00:00Z	
9	Diastolic Blood Pressure	80.0	mmHg	2025-08-03T00:00:00Z	
10	Heart rate	72.0	beats/min	2025-08-03T00:00:00Z	
11	Glucose	97.2	mg/dL	2025-08-03T00:00:00Z	
12	Systolic Blood Pressure	117.0	mmHg	2025-08-04T00:00:00Z	
13	Diastolic Blood Pressure	71.0	mmHg	2025-08-04T00:00:00Z	
14	Heart rate	83.0	beats/min	2025-08-04T00:00:00Z	
15	Glucose	95.5	mg/dL	2025-08-04T00:00:00Z	
16	Systolic Blood Pressure	118.0	mmHg	2025-08-05T00:00:00Z	
17	Diastolic Blood Pressure	86.0	mmHg	2025-08-05T00:00:00Z	
18	Heart rate	65.0	beats/min	2025-08-05T00:00:00Z	
19	Glucose	106.2	mg/dL	2025-08-05T00:00:00Z	

```

In [27]: medications = [
    {
        "resourceType": "MedicationStatement",
        "status": "active",
        "medicationCodeableConcept": {"text": "Lisinopril 10mg tablet"},
        "subject": {"reference": f"Patient/{patient_id}"},
        "effectiveDateTime": "2025-09-10T11:00:00Z"
    },
    {
        "resourceType": "MedicationStatement",
        "status": "active",
        "medicationCodeableConcept": {"text": "Lisinopril 10mg tablet"},
        "subject": {"reference": f"Patient/{patient_id}"},
        "effectiveDateTime": "2025-09-11T11:30:00Z"
    },
    {
        "resourceType": "MedicationStatement",
        "status": "active",
        "medicationCodeableConcept": {"text": "Lisinopril 20mg tablet"},
        "subject": {"reference": f"Patient/{patient_id}"},
        "effectiveDateTime": "2025-09-12T12:00:00Z"
    }
]

```



```
for med in medications:
    r = requests.post(f"{FHIR_BASE}/MedicationStatement", json=med)
    print("Med:", r.status_code, r.json().get("id"))
```

Med: 201 49233433

Med: 201 49233434

Med: 201 49233435

In [30]: patient_id

Out[30]: '49233412'

In [28]: *# Now that we have our fake patient set up, let's go back to the goal and pull their data*

Observations

```
obs_resp = requests.get(f"{FHIR_BASE}/Observation", params={"patient": patient_id})
```

```
print("----- OBSERVATIONS -----")
```

```
print(len(obs_resp.json().get("entry", [])), "observations")
```

```
observations = []
```

```
for entry in obs_resp.json().get("entry", []):
```

```
    resource = entry["resource"]
```

```
    code = resource.get("code", {}).get("text")
```

```
    value = resource.get("valueQuantity", {}).get("value")
```

```
    unit = resource.get("valueQuantity", {}).get("unit")
```

```
    time = resource.get("effectiveDateTime")
```

```
    if value:
```

```
        observations.append({"code": code, "value": value, "unit": unit, "time": time})
```

```
df = pd.DataFrame(observations)
```

```
print(df)
```

Medications

```
print("\n----- MEDICATIONS -----")
```

```
med_resp = requests.get(f"{FHIR_BASE}/MedicationStatement", params={"patient": patient_id})
```

```
for e in med_resp.json().get("entry", []):
```

```
    print("Medication:", e["resource"].get("medicationCodeableConcept", {}).get("text"))
```

----- OBSERVATIONS -----

20 observations

		code	value	unit	time
0	Systolic Blood Pressure		115.0	mmHg	2025-08-01T00:00:00Z
1	Diastolic Blood Pressure		83.0	mmHg	2025-08-01T00:00:00Z
2	Heart rate		82.0	beats/min	2025-08-01T00:00:00Z
3	Glucose		109.1	mg/dL	2025-08-01T00:00:00Z
4	Systolic Blood Pressure		115.0	mmHg	2025-08-02T00:00:00Z
5	Diastolic Blood Pressure		73.0	mmHg	2025-08-02T00:00:00Z
6	Heart rate		89.0	beats/min	2025-08-02T00:00:00Z
7	Glucose		73.5	mg/dL	2025-08-02T00:00:00Z
8	Systolic Blood Pressure		118.0	mmHg	2025-08-03T00:00:00Z
9	Diastolic Blood Pressure		80.0	mmHg	2025-08-03T00:00:00Z
10	Heart rate		72.0	beats/min	2025-08-03T00:00:00Z
11	Glucose		97.2	mg/dL	2025-08-03T00:00:00Z
12	Systolic Blood Pressure		117.0	mmHg	2025-08-04T00:00:00Z
13	Diastolic Blood Pressure		71.0	mmHg	2025-08-04T00:00:00Z
14	Heart rate		83.0	beats/min	2025-08-04T00:00:00Z
15	Glucose		95.5	mg/dL	2025-08-04T00:00:00Z
16	Systolic Blood Pressure		118.0	mmHg	2025-08-05T00:00:00Z
17	Diastolic Blood Pressure		86.0	mmHg	2025-08-05T00:00:00Z
18	Heart rate		65.0	beats/min	2025-08-05T00:00:00Z
19	Glucose		106.2	mg/dL	2025-08-05T00:00:00Z

----- MEDICATIONS -----

Medication: Lisinopril 10mg tablet

Medication: Lisinopril 10mg tablet

Medication: Lisinopril 20mg tablet

In [29]: *# ok now let's plot!*

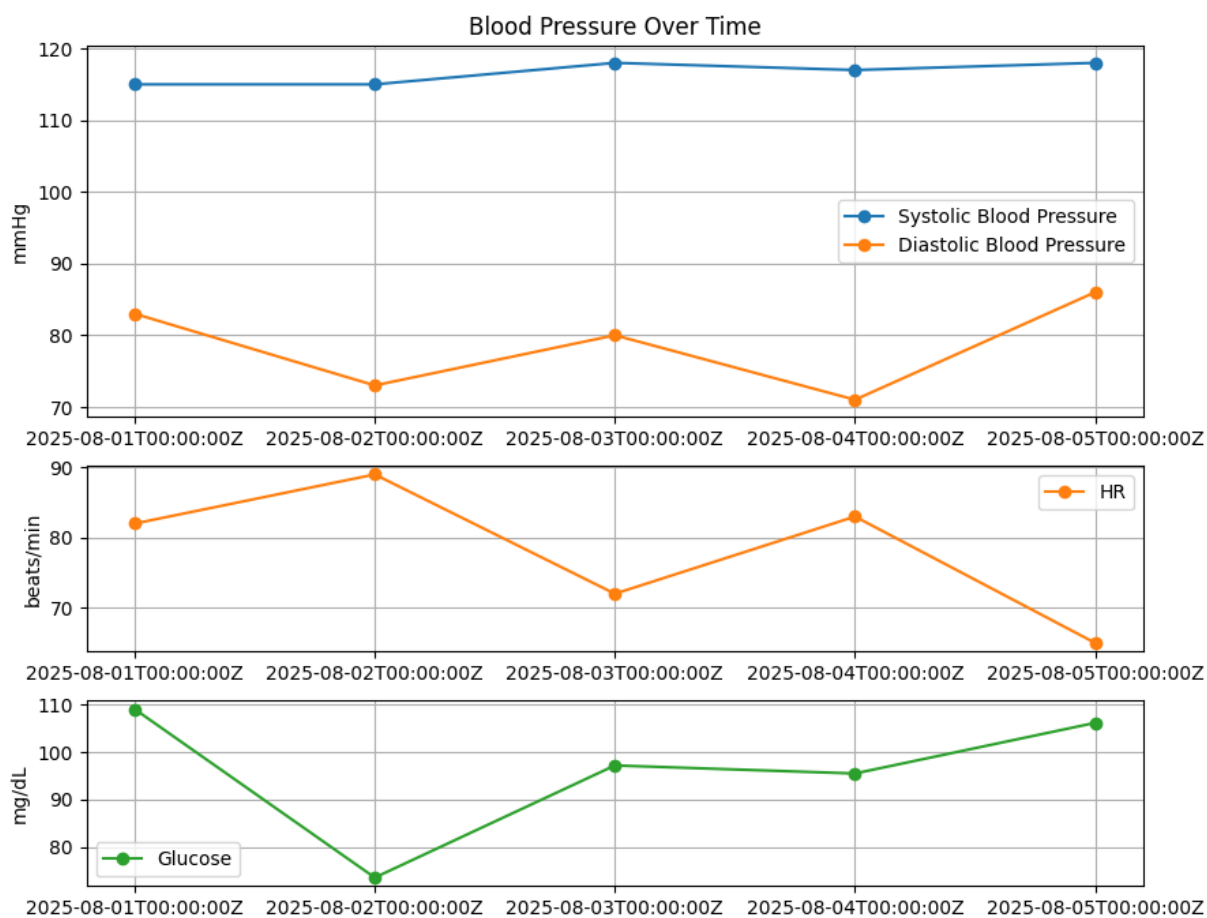
```
fig, axes = plt.subplots(3, 1, figsize=(10, 8), gridspec_kw={"height_ratios":

# show bp on one plot
bp = df[df["code"].str.contains("Blood Pressure")]
for code in ["Systolic Blood Pressure", "Diastolic Blood Pressure"]:
    subset = bp[bp["code"] == code]
    axes[0].plot(subset["time"], subset["value"], marker="o", label=code)
axes[0].set_ylabel("mmHg")
axes[0].set_title("Blood Pressure Over Time")
axes[0].legend()
axes[0].grid(True)

hr = df[df["code"] == "Heart rate"]
axes[1].plot(hr["time"], hr["value"], marker="o", color="tab:orange", label="")
axes[1].set_ylabel("beats/min")
axes[1].legend()
axes[1].grid(True)

glucose = df[df["code"] == "Glucose"]
axes[2].plot(glucose["time"], glucose["value"], marker="o", color="tab:green")
axes[2].set_ylabel("mg/dL")
axes[2].legend()
axes[2].grid(True)
```

```
plt.show()
```



```
In [ ]: # if you made it this far congratulations! To extend your knowledge, please
# find a new resource type on the FHIR specification, make some synthetic data
# and retrieve it, showing the data however you like.

# you can browse resources here: https://build.fhir.org/resource-list.html
```