alistairewj remove large dataframe display from output

`8bcc875` on 4 Nov 2017

1 contributor

Raw | Blame | History

`4975 lines (4974 sloc)  532 KB`

Continuous renal replacement therapy (CRRT)

This notebook overviews the process of defining CRRT: a treatment used to dialyse or filter a patient's blood continuously. Key to CRRT is its lower speed compared to conventional dialysis: avoidance of rapid solute/fluid loss is suspected to be the main reason why CRRT tends to be tolerated better than intermittent hemodialysis.

The primary aim of this notebook is to define the start and end times of CRRT for patients in the MIMIC-III database v1.4.

A secondary aim of this notebook is to provide insight into how to extract clinical concepts from the MIMIC-III database.

Many thanks to Sharon O'Donoghue for her invaluable advice in the creation of this notebook.

Outline

The main steps in defining a clinical concept in MIMIC-III are as follows:

1. Identification of key terms and phrases which describe the concept
2. Search for these terms in D_ITEMS (or D_LABITEMS if searching for a laboratory measurement)
3. Extraction of the data from tables specified in the LINKSTO column of D_ITEMS
4. Definition of the concept using rules applied to the data extracted
5. Validation of the concepts by individual inspection and aggregate statistics

This process is iterative and not as clear cut as the above - validation may lead you to redefine data extraction, and so on. Furthermore, in the case of MIMIC-III v1.4, this process must be repeated twice: once for Metavision, once for CareVue.

MetaVision vs. CareVue

One issue in MIMIC-III is that it is a combination of two ICU database systems. As a result, concepts are split among different ITEMID values. For example, a patient's heart rate is a relatively simple concept to extract, however, if we look in the D_ITEMS table for labels matching 'heart rate', we find at least two ITEMID:

itemid	label	abbreviation	dbsource	linksto
211	Heart Rate		carevue	chartevents
220045	Heart Rate	HR	metavision	chartevents

Both these ITEMID values capture heart rate - but one is used for the CareVue database system (dbsource = 'carevue') and one is used for the MetaVision database system (dbsource = 'metavision'). The data extraction step must be repeated twice: once for dbsource = 'carevue' and once for dbsource = 'metavision'. In general, it is recommended to extract data from MetaVision first, as the data is better structured and provides useful information for what data elements to include. For example, ITEMID values in MetaVision have abbrevations with each label - these abbreviations can then be used to search for data elements in CareVue.

Step 0: import libraries, connect to the database

In [1]:
```
# Import libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import psycopg2
from IPython.display import display, HTML # used to print out pretty pandas dataframes
import matplotlib.dates as dates
import matplotlib.lines as mlines

%matplotlib inline
plt.style.use('ggplot')

# specify user/password/where the database is
sqluser = 'postgres'
sqlpass = 'postgres'
dbname = 'mimic'
schema_name = 'mimiciii'
host = 'localhost'

query_schema = 'SET search_path to ' + schema_name + ';'

# connect to the database
con = psycopg2.connect(dbname=dbname, user=sqluser, password=sqlpass, host=host)
```

Step 1: Identification of key terms

We are interested in continuous renal replacement therapy (CRRT). First, we look for 'CRRT' in the database, isolating ourselves to metavision data:

metavision data.

In [2]:
```
query = query_schema + """
select itemid, label, category, linksto
from d_items
where dbsource = 'metavision'
and lower(label) like '%crrt%'
"""
df = pd.read_sql_query(query,con)

df
```

Out[2]:

	itemid	label	category	linksto
0	227290	CRRT mode	Dialysis	chartevents
1	225436	CRRT Filter Change	Dialysis	procedureevents_mv
2	227525	Calcium Gluconate (CRRT)	Medications	inputevents_mv
3	225802	Dialysis - CRRT	Dialysis	procedureevents_mv
4	227536	KCl (CRRT)	Medications	inputevents_mv
5	225956	Reason for CRRT Filter Change	Dialysis	chartevents

The above gives us some hints to expand our initial search:

- category = 'Dialysis'
- lower(label) like '%dialysis%'

Step 2: Extraction of ITEMIDs from tables

Get list of itemid related to CRRT

In [3]:
```
query = query_schema + """
select itemid, label, category, linksto
from d_items di
where dbsource = 'metavision'
and (lower(label) like '%dialy%'
or category = 'Dialysis'
or lower(label) like '%crrt%'
)
order by linksto, category, label
"""
df = pd.read_sql_query(query,con)

HTML(df.head().to_html().replace('NaN', ''))
```

Out[3]:

	itemid	label	category	linksto
0	225740	Dialysis Catheter Discontinued	Access Lines - Invasive	chartevents
1	227357	Dialysis Catheter Dressing Occlusive	Access Lines - Invasive	chartevents
2	225776	Dialysis Catheter Dressing Type	Access Lines - Invasive	chartevents
3	226118	Dialysis Catheter placed in outside facility	Access Lines - Invasive	chartevents
4	227753	Dialysis Catheter Placement Confirmed by X-ray	Access Lines - Invasive	chartevents

Manually label above itemid

The above is a list of all the potential data elements which could be used to define CRRT. The next step is to identify the specific elements which can be used to define start/stop time. This process requires clinical expertise in the area.

The following tables are a result of reviewing all ITEMID labels and flagging them as "consider for further review" or "not relevant".

Links to CHARTEVENTS

itemid	label	category	linksto	Included/comment
225740	Dialysis Catheter Discontinued	Access Lines - Invasive	chartevents	No - access line
227357	Dialysis Catheter Dressing Occlusive	Access Lines - Invasive	chartevents	No - access line
225776	Dialysis Catheter Dressing Type	Access Lines - Invasive	chartevents	No - access line
226118	Dialysis Catheter placed in outside facility	Access Lines - Invasive	chartevents	No - access line
227753	Dialysis Catheter Placement Confirmed by X-ray	Access Lines - Invasive	chartevents	No - access line

225323	Dialysis Catheter Site Appear	Access Lines - Invasive	chartevents	No - access line
225725	Dialysis Catheter Tip Cultured	Access Lines - Invasive	chartevents	No - access line
227124	Dialysis Catheter Type	Access Lines - Invasive	chartevents	No - access line
225126	Dialysis patient	Adm History/FHPA	chartevents	No - admission information
224149	Access Pressure	Dialysis	chartevents	Yes - CRRT setting
224404	ART Lumen Volume	Dialysis	chartevents	Yes - CRRT setting
224144	Blood Flow (ml/min)	Dialysis	chartevents	Yes - CRRT setting
228004	Citrate (ACD-A)	Dialysis	chartevents	Yes - CRRT setting
227290	CRRT mode	Dialysis	chartevents	Yes - CRRT setting
225183	Current Goal	Dialysis	chartevents	Yes - CRRT setting
225977	Dialysate Fluid	Dialysis	chartevents	Yes - CRRT setting
224154	Dialysate Rate	Dialysis	chartevents	Yes - CRRT setting
224135	Dialysis Access Site	Dialysis	chartevents	No - access line
225954	Dialysis Access Type	Dialysis	chartevents	No - access line
224139	Dialysis Site Appearance	Dialysis	chartevents	No - access line
225810	Dwell Time (Peritoneal Dialysis)	Dialysis	chartevents	No - peritoneal dialysis
224151	Effluent Pressure	Dialysis	chartevents	Yes - CRRT setting
224150	Filter Pressure	Dialysis	chartevents	Yes - CRRT setting
226499	Hemodialysis Output	Dialysis	chartevents	No - hemodialysis
225958	Heparin Concentration (units/mL)	Dialysis	chartevents	Yes - CRRT setting
224145	Heparin Dose (per hour)	Dialysis	chartevents	Yes - CRRT setting
224191	Hourly Patient Fluid Removal	Dialysis	chartevents	Yes - CRRT setting
225952	Medication Added #1 (Peritoneal Dialysis)	Dialysis	chartevents	No - peritoneal dialysis
227638	Medication Added #2 (Peritoneal Dialysis)	Dialysis	chartevents	No - peritoneal dialysis
225959	Medication Added Amount #1 (Peritoneal Dialysis)	Dialysis	chartevents	No - peritoneal dialysis
227639	Medication Added Amount #2 (Peritoneal Dialysis)	Dialysis	chartevents	No - peritoneal dialysis
225961	Medication Added Units #1 (Peritoneal Dialysis)	Dialysis	chartevents	No - peritoneal dialysis
227640	Medication Added Units #2 (Peritoneal Dialysis)	Dialysis	chartevents	No - peritoneal dialysis
228005	PBP (Prefilter) Replacement Rate	Dialysis	chartevents	Yes - CRRT setting
225965	Peritoneal Dialysis Catheter Status	Dialysis	chartevents	No - peritoneal dialysis
225963	Peritoneal Dialysis Catheter Type	Dialysis	chartevents	No - peritoneal dialysis
225951	Peritoneal Dialysis Fluid Appearance	Dialysis	chartevents	No - peritoneal dialysis
228006	Post Filter Replacement Rate	Dialysis	chartevents	Yes - CRRT setting
225956	Reason for CRRT Filter Change	Dialysis	chartevents	Yes - CRRT setting
225976	Replacement Fluid	Dialysis	chartevents	Yes - CRRT setting
224153	Replacement Rate	Dialysis	chartevents	Yes - CRRT setting
224152	Return Pressure	Dialysis	chartevents	Yes - CRRT setting
225953	Solution (Peritoneal Dialysis)	Dialysis	chartevents	No - peritoneal dialysis
224146	System Integrity	Dialysis	chartevents	Yes - CRRT setting
226457	Ultrafiltrate Output	Dialysis	chartevents	Yes - CRRT setting
224406	VEN Lumen Volume	Dialysis	chartevents	Yes - CRRT setting
225806	Volume In (PD)	Dialysis	chartevents	No - peritoneal dialysis
227438	Volume not removed	Dialysis	chartevents	No - peritoneal dialysis
225807	Volume Out (PD)	Dialysis	chartevents	No - peritoneal dialysis

Links to DATETIMEEVENTS

itemid	label	category	linksto	Included/comment
225318	Dialysis Catheter Cap Change	Access Lines - Invasive	datetimeevents	No - access lines
225319	Dialysis Catheter Change over Wire Date	Access Lines - Invasive	datetimeevents	No - access lines
225321	Dialysis Catheter Dressing Change	Access Lines - Invasive	datetimeevents	No - access lines

225322	Dialysis Catheter Insertion Date	Access Lines - Invasive	datetimeevents	No - access lines
225324	Dialysis CatheterTubing Change	Access Lines - Invasive	datetimeevents	No - access lines
225128	Last dialysis	Adm History/FHPA	datetimeevents	No - admission information

Links to INPUTEVENTS_MV

itemid	label	category	linksto	Included/comment
227525	Calcium Gluconate (CRRT)	Medications	inputevents_mv	Yes - CRRT setting
227536	KCl (CRRT)	Medications	inputevents_mv	Yes - CRRT setting

Links to PROCEDUREEVENTS_MV

itemid	label	category	linksto	Included/comment
225441	Hemodialysis	4-Procedures	procedureevents_mv	No - hemodialysis
224270	Dialysis Catheter	Access Lines - Invasive	procedureevents_mv	No - access lines
225436	CRRT Filter Change	Dialysis	procedureevents_mv	Yes - CRRT setting
225802	Dialysis - CRRT	Dialysis	procedureevents_mv	Yes - CRRT setting
225803	Dialysis - CVVHD	Dialysis	procedureevents_mv	Yes - CRRT setting
225809	Dialysis - CVVHDF	Dialysis	procedureevents_mv	Yes - CRRT setting
225955	Dialysis - SCUF	Dialysis	procedureevents_mv	Yes - CRRT setting
225805	Peritoneal Dialysis	Dialysis	procedureevents_mv	No - peritoneal dialysis

Reasons for inclusion/exclusion

- CRRT Setting - yes (included) - these settings are only documented when a patient is receiving CRRT.
- Access lines- no (excluded) - these ITEMIDs are not included as the presence of an access line does *not* guarantee that CRRT is being delivered. While having an access line is a requirement of performing CRRT, these lines are present even when a patient is not actively being hemodialysed.
- Peritoneal dialysis - no (excluded) - Peritoneal dialysis is a different form of dialysis, and is not CRRT
- Hemodialysis - no (excluded) - Similar as above, hemodialysis is a different form of dialysis and is not CRRT

Define rules based upon ITEMIDs

Above, we acquired a list of itemid which we determined to be related to administration of CRRT. The next step is to determine *how* these itemid relate to CRRT: do they indicate it is started, stopped, continuing, or something else.

We will evaluate itemid from three tables, in turn: CHARTEVENTS, INPUTEVENTS_MV, and PROCEDUREEVENTS_MV. Note that the _MV subscript indicates that the table only has data from MetaVision (half the patients), while _CV indicates the table only has data from CareVue (the other half of patients). Note that after we extract data from MetaVision patients, we will repeat this exercise for CareVue patients.

table 1 of 3: itemid from CHARTEVENTS

These are the included CRRT settings in CHARTEVENTS:

itemid	label	param_type
224144	Blood Flow (ml/min)	Numeric
224145	Heparin Dose (per hour)	Numeric
224146	System Integrity	Text
224149	Access Pressure	Numeric
224150	Filter Pressure	Numeric
224151	Effluent Pressure	Numeric
224152	Return Pressure	Numeric
224153	Replacement Rate	Numeric
224154	Dialysate Rate	Numeric
224191	Hourly Patient Fluid Removal	Numeric
224404	ART Lumen Volume	Numeric
224406	VEN Lumen Volume	Numeric
225183	Current Goal	Numeric

225956	Reason for CRRT Filter Change	Text
225958	Heparin Concentration (units/mL)	Text
225976	Replacement Fluid	Text
225977	Dialysate Fluid	Text
226457	Ultrafiltrate Output	Numeric
227290	CRRT mode	Text
228004	Citrate (ACD-A)	Numeric
228005	PBP (Prefilter) Replacement Rate	Numeric
228006	Post Filter Replacement Rate	Numeric

First, we examine the numeric fields. These fields are the core CRRT settings which, according to clinical advice, should be documented hourly for patients actively on CRRT:

In [4]:
```
query = query_schema + """
select
  ce.icustay_id, di.label, ce.charttime
  , ce.value
  , ce.valueuom
from chartevents ce
inner join d_items di
on ce.itemid = di.itemid
where ce.icustay_id = 246866
and ce.itemid in
(
      224404, -- | ART Lumen Volume
      224406, -- | VEN Lumen Volume
      228004, -- | Citrate (ACD-A)
      224145, -- | Heparin Dose (per hour)
      225183, -- | Current Goal
      224149, -- | Access Pressure
      224144, -- | Blood Flow (ml/min)
      224154, -- | Dialysate Rate
      224151, -- | Effluent Pressure
      224150, -- | Filter Pressure
      224191, -- | Hourly Patient Fluid Removal
      228005, -- | PBP (Prefilter) Replacement Rate
      228006, -- | Post Filter Replacement Rate
      224153, -- | Replacement Rate
      224152, -- | Return Pressure
      226457  -- | Ultrafiltrate Output
)
order by ce.icustay_id, ce.charttime, di.label;
"""
df = pd.read_sql_query(query,con)

HTML(df.head().to_html().replace('NaN', ''))
```

Out[4]:

	icustay_id	label	charttime	value	valueuom
0	246866	ART Lumen Volume	2161-12-11 20:00:00	1.3	mL
1	246866	VEN Lumen Volume	2161-12-11 20:00:00	1.2	mL
2	246866	Access Pressure	2161-12-11 23:43:00	-87	mmHg
3	246866	Blood Flow (ml/min)	2161-12-11 23:43:00	200	ml/min
4	246866	Citrate (ACD-A)	2161-12-11 23:43:00	0	ml/hr

Above we can see that ART Lumen Volume and VEN Lumen Volume are documented at a drastically different time than the other settings. Upon discussion with a clinical expert, they confirmed that this is expected, as these volumes indicate settings to keep open the line and are not directly relevant to the administration of CRRT - at best they are superfluous and at worst they can mislead the start/stop times. As a result ART Lumen Volume and VEN Lumen Volume are excluded. This leaves us with the final set of ITEMIDs:

224149, – *Access Pressure*
224144, – *Blood Flow (ml/min)*
228004, – *Citrate (ACD-A)*
225183, – *Current Goal*
224154, – *Dialysate Rate*
224151, – *Effluent Pressure*
224150, – *Filter Pressure*
224145, – *Heparin Dose (per hour)*
224191, – *Hourly Patient Fluid Removal*
228005, – *PBP (Prefilter) Replacement Rate*
228006, – *Post Filter Replacement Rate*
224153, – *Replacement Rate*

224152, – *Return Pressure*
226457 – *Ultrafiltrate Output*

The next step is to examine the remaining text based ITEMID:

itemid	label	param_type
224146	System Integrity	Text
225956	Reason for CRRT Filter Change	Text
225958	Heparin Concentration (units/mL)	Text
225976	Replacement Fluid	Text
225977	Dialysate Fluid	Text
227290	CRRT mode	Text

We define a helper function which prints out the number of observations for a given itemid:

In [5]:
```
def print_itemid_info(con, itemid):
    # get name of itemid
    query = query_schema + """
    select label
    from d_items
    where itemid = """ + str(itemid)

    df = pd.read_sql_query(query,con)
    print('Values for {} - {}...'.format(itemid, df['label'][0]))


    query = query_schema + """
    select value
    , count(distinct icustay_id) as number_of_patients
    , count(icustay_id) as number_of_observations
    from chartevents
    where itemid = """ + str(itemid) + """
    group by value
    order by value
    """
    df = pd.read_sql_query(query,con)
    display(HTML(df.to_html().replace('NaN', '')))
```

224146 - System Integrity

In [6]:
```
print_itemid_info(con, 224146)
```

Values for 224146 - System Integrity...

	value	number_of_patients	number_of_observations
0	Active	539	48072
1	Clots Increasing	245	1419
2	Clots Present	427	16836
3	Clotted	233	441
4	Discontinued	339	771
5	Line pressure inconsistent	127	431
6	New Filter	357	1040
7	No Clot Present	275	2615
8	Recirculating	172	466
9	Reinitiated	336	1207

In discussion with a clinical expert, each of these settings indicate different stages of the CRRT treatment. We can simplify them into three modes: started, stopped, or active. Since active implies that the CRRT is running, the first active event could also be a start time, therefore we call it "active/started". Here we list the manually curated mapping:

value	count	interpretation
Active	539	CRRT active/started
Clots Increasing	245	CRRT active/started
Clots Present	427	CRRT active/started
Clotted	233	CRRT **stopped**
Discontinued	339	CRRT **stopped**

Line pressure inconsistent	127	CRRT active/started
New Filter	357	CRRT **started**
No Clot Present	275	CRRT active/started
Recirculating	172	CRRT **stopped**
Reinitiated	336	CRRT **started**

Later on we will code special rules to incorporate this itemid.

225956 - Reason for CRRT Filter Change

In [7]:
```
print_itemid_info(con, 225956)
```

Values for 225956 - Reason for CRRT Filter Change...

	value	number_of_patients	number_of_observations
0	Clotted	50	69
1	Line changed	9	11
2	Procedure	20	31

The above is a **stop** time as the filter needed to be changed at this time. Any subsequent CRRT would be a restart of CRRT - and not a continuation of an ongoing CRRT session.

225958 - Heparin Concentration (units/mL)

In [8]:
```
print_itemid_info(con, 225958)
```

Values for 225958 - Heparin Concentration (units/mL)...

	value	number_of_patients	number_of_observations
0	100	16	995
1	1000	41	94
2	Not applicable	120	8796

The above is a normal setting and can be combined with the numeric fields.

225976 - Replacement Fluid

In [9]:
```
print_itemid_info(con, 225976)
```

Values for 225976 - Replacement Fluid...

	value	number_of_patients	number_of_observations
0	None	14	19
1	Normal Saline 0.9%	1	12
2	Prismasate K0	78	201
3	Prismasate K2	459	27603
4	Prismasate K4	387	30872
5	Sodium Bicarb 150/D5W	2	8
6	Sodium Bicarb 75/0.45NS	6	48

The above is a normal setting and can be combined with the numeric fields.

225977 - Dialysate Fluid

In [10]:
```
print_itemid_info(con, 225977)
```

Values for 225977 - Dialysate Fluid...

	value	number_of_patients	number_of_observations
0	None	97	6025
1	Normal Saline	32	695

2	Prismasate K0	89	231
3	Prismasate K2	438	24271
4	Prismasate K4	357	27320

The above is a normal setting and can be combined with the numeric fields.

227290 - CRRT mode

In [11]:
```
print_itemid_info(con, 227290)
```

Values for 227290 - CRRT mode...

	value	number_of_patients	number_of_observations
0	CVVH	40	1280
1	CVVHD	24	583
2	CVVHDF	498	25533
3	SCUF	1	7

While all of this looks good, it's feasible that the documentation of the CRRT mode is not done directly concurrent to the actual administration of CRRT. We thus investigate whether CRRT mode is available for all patients with a CRRT setting.

In [12]:
```
# Examining CRRT mode
query = query_schema + """
with t1 as
(
select icustay_id,
    max(case when itemid = 227290 then 1 else 0 end) as HasMode
from chartevents ce
where itemid in
(
        227290, -  CRRT mode
        228004, -  Citrate (ACD-A)
        225958, -  Heparin Concentration (units/mL)
        224145, -  Heparin Dose (per hour)
        225183, -  Current Goal - always there
        224149, -  Access Pressure
        224144, -  Blood Flow (ml/min)
        225977, -  Dialysate Fluid
        224154, -  Dialysate Rate
        224151, -  Effluent Pressure
        224150, -  Filter Pressure
        224191, -  Hourly Patient Fluid Removal
        228005, -  PBP (Prefilter) Replacement Rate
        228006, -  Post Filter Replacement Rate
        225976, -  Replacement Fluid
        224153, -  Replacement Rate
        224152, -  Return Pressure
        226457  -  Ultrafiltrate Output
)
group by icustay_id
)
select count(icustay_id) as Num_ICUSTAY_ID
, sum(hasmode) as Num_With_Mode
from t1
"""
df = pd.read_sql_query(query,con)

HTML(df.to_html().replace('NaN', ''))
```

Out[12]:

	num_icustay_id	num_with_mode
0	784	533

We can take this analysis a bit further and ask: is CRRT mode is present when *none* of the other settings are present?

In [13]:
```
query = query_schema + """
with t1 as
(
select icustay_id, charttime
    , max(case when itemid = 227290 then 1 else 0 end) as HasCRRTMode
    , max(case when itemid != 227290 then 1 else 0 end) as OtherITEMID
from chartevents ce
where itemid in
(
```

```
        227290, -- CRRT mode
        228004, -- Citrate (ACD-A)
        225958, -- Heparin Concentration (units/mL)
        224145, -- Heparin Dose (per hour)
        225183, -- Current Goal -- always there
        224149, -- Access Pressure
        224144, -- Blood Flow (ml/min)
        225977, -- Dialysate Fluid
        224154, -- Dialysate Rate
        224151, -- Effluent Pressure
        224150, -- Filter Pressure
        224191, -- Hourly Patient Fluid Removal
        228005, -- PBP (Prefilter) Replacement Rate
        228006, -- Post Filter Replacement Rate
        225976, -- Replacement Fluid
        224153, -- Replacement Rate
        224152, -- Return Pressure
        226457  -- Ultrafiltrate Output
)
group by icustay_id, charttime
)
select count(icustay_id) as NumObs
, sum(case when HasCRRTMode = 1 and OtherITEMID = 1 then 1 else 0 end) as Both
, sum(case when HasCRRTMode = 1 and OtherITEMID = 0 then 1 else 0 end) as OnlyCRRTMode
, sum(case when HasCRRTMode = 0 and OtherITEMID = 1 then 1 else 0 end) as NoCRRTMode
from t1
"""
df = pd.read_sql_query(query,con)

HTML(df.to_html().replace('NaN', ''))
```

Out[13]:

	numobs	both	onlycrrtmode	nocrrtmode
0	81162	27446	1	53778

As CRRT mode is relatively redundant, doesn't necessarily indicate CRRT is being actively performed, and documentation for it is not 100% compliant, we exclude it from the list of ITEMID.

CHARTEVENTS wrap up

The following is the final set of ITEMID from CHARTEVENTS which indicate CRRT is started/ongoing:

224149, – *Access Pressure*
224144, – *Blood Flow (ml/min)*
228004, – *Citrate (ACD-A)*
225183, – *Current Goal*
225977, – *Dialysate Fluid*
224154, – *Dialysate Rate*
224151, – *Effluent Pressure*
224150, – *Filter Pressure*
225958, – *Heparin Concentration (units/mL)*
224145, – *Heparin Dose (per hour)*
224191, – *Hourly Patient Fluid Removal*
228005, – *PBP (Prefilter) Replacement Rate*
228006, – *Post Filter Replacement Rate*
225976, – *Replacement Fluid*
224153, – *Replacement Rate*
224152, – *Return Pressure*
226457 – *Ultrafiltrate Output*

The following ITEMID are the final set which indicate CRRT is started/stopped/ongoing (i.e. require special rules):

224146, – *System Integrity*
225956 – *Reason for CRRT Filter Change*

table 2 of 3: INPUTEVENTS_MV

The following is the final set of ITEMID from INPUTEVENTS_MV:

227525,– *Calcium Gluconate (CRRT)*
227536 – *KCl (CRRT)*

No special examination is required for these fields - they are guaranteed to be CRRT (as verified by a clinician) - we can use these to indicate that CRRT is active/started.

table 3 of 3: PROCEDUREEVENTS_MV

The following are the set of itemid from above related to PROCEDUREEVENTS_MV:

itemid	label
225436	CRRT Filter Change
225802	Dialysis - CRRT
225803	Dialysis - CVVHD
225809	Dialysis - CVVHDF
225955	Dialysis - SCUF

The only contentious ITEMID is 225436 (CRRT Filter Change). This ITEMID indicates a break from CRRT, and it reinitiates at the end of this change. While in principle this could be used as an end time, documentation on it is not 100%, and as recommended by staff it's easier to ignore this and use the filter change field from CHARTEVENTS to define the end of CRRT events.

The final set of ITEMID used for CRRT are:

225802, – *Dialysis - CRRT*
225803, – *Dialysis - CVVHD*
225809, – *Dialysis - CVVHDF*
225955 – *Dialysis - SCUF*

Step 4: definition of concept using rules

Let's review the goal of this notebook. We would like to define the duration of CRRT for each patient. Concretely, this means we must define, for each ICUSTAY_ID:

- a STARTTIME
- an ENDTIME

As CRRT can be started/stopped throughout a patient's stay, there may be multiple STARTTIME and ENDTIME for a single ICUSTAY_ID - but they should not overlap.

Recall that CHARTEVENTS stores data at charted times (CHARTTIME), and as a result the settings are stored at a single point in time. For CHARTEVENTS, the main task thus becomes converting a series of CHARTTIME into pairs of STARTTIME and ENDTIME. Intuitively this can be done by looking for consecutive settings each hour, and combining these into a single CRRT event. The first observed CHARTTIME becomes the STARTTIME, and the last observed CHARTTIME becomes the ENDTIME. However, CHARTEVENTS is not the only source of data. To improve the accuracy of our calculation, we also include data from INPUTEVENTS_MV and PROCEDUREEVENTS_MV. For INPUTEVENTS_MV, this does not complicate things too much. Each observation in INPUTEVENTS_MV is also stored at a single CHARTTIME, and so we simply need to combine this table with CHARTEVENTS before proceeding (likely by using the SQL UNION command).

PROCEDUREEVENTS_MV is more complicated as it actually stores data with a STARTTIME and an ENDTIME column already. We need to merge the extracted data from CHARTEVENTS/INPUTEVENTS_MV with this already nicely formatted data from PROCEDUREEVENTS_MV.

With the task laid out, let's get started. We will:

1. Aggregate INPUTEVENTS_MV into durations
2. Convert CHARTEVENTS into durations
3. Compare these durations with PROCEDUREVENTS_MV and decide on a rule for merging the two
4. Merge PROCEDUREEVENTS_MV with INPUTEVENTS_MV/CHARTEVENTS for a final durations table for Metavision

In [14]:
```
# define the example ICUSTAY_ID for the below code
# originally, this was 246866 - if changed, the interpretation provided will no longer make sense
query_where_clause = "and icustay_id = 246866"
```

To make sure we don't display data we don't have to, we define a function which: (i) doesn't display icustay_id, and (ii) simplifies the date by removing the month/year.

In [15]:
```
def display_df(df):
    col = [x for x in df.columns if x != 'icustay_id']
    df_tmp = df[col].copy()
    for c in df_tmp.columns:
        if '[ns]' in str(df_tmp[c].dtype):
            df_tmp[c] = df_tmp[c].dt.strftime('Day %d, %H:%M')

    display(HTML(df_tmp.to_html().replace('NaN', '')))
```

Aggregating INPUTEVENTS_MV

First, let's look at INPUTEVENTS_MV. Each entry is stored with a starttime and an endtime. Note we have to exclude statusdescription = 'Rewritten' as these are undelivered medications which have been rewritten (useful for auditing purposes but does not give you information about drugs delivered to the patient).

In [16]:
```
print("Durations from INPUTEVENTS for one patient with KCl...")
query = query_schema + """
select
    linkorderid
  , orderid
  , case when itemid = 227525 then 'Calcium' else 'KCl' end as label
  , starttime, endtime
  , rate, rateuom
  , statusdescription
from inputevents_mv
where itemid in
(
  --227525,-- Calcium Gluconate (CRRT)
  227536 -- KCl (CRRT)
)
and statusdescription != 'Rewritten'
""" + query_where_clause + """
order by starttime, endtime
"""
ie = pd.read_sql_query(query,con)

display_df(ie)
```

Durations from INPUTEVENTS for one patient with KCl...

	linkorderid	orderid	label	starttime	endtime	rate	rateuom	statusdescription
0	8522257	8522257	KCl	Day 11, 21:30	Day 12, 02:30	4.000000	mEq./hour	FinishedRunning
1	9370484	9370484	KCl	Day 11, 23:45	Day 12, 02:41	10.002273	mEq./hour	FinishedRunning
2	3507252	3507252	KCl	Day 12, 02:41	Day 12, 05:36	9.997713	mEq./hour	FinishedRunning
3	9525961	9525961	KCl	Day 12, 05:36	Day 12, 08:31	10.285715	mEq./hour	FinishedRunning
4	7118985	7118985	KCl	Day 12, 08:31	Day 12, 11:29	10.112360	mEq./hour	FinishedRunning
5	5395095	5395095	KCl	Day 12, 11:29	Day 12, 14:28	10.055866	mEq./hour	FinishedRunning
6	8065541	8065541	KCl	Day 12, 14:28	Day 12, 17:25	10.169492	mEq./hour	FinishedRunning
7	5758899	5758899	KCl	Day 12, 17:25	Day 12, 20:24	10.055866	mEq./hour	FinishedRunning
8	7157126	7157126	KCl	Day 12, 20:24	Day 12, 20:30	10.000000	mEq./hour	Paused
9	7157126	3853798	KCl	Day 12, 21:30	Day 12, 21:35	9.997634	mEq./hour	Changed
10	7157126	6292957	KCl	Day 12, 21:35	Day 13, 02:08	6.190549	mEq./hour	FinishedRunning
11	271343	271343	KCl	Day 13, 02:08	Day 13, 07:06	6.040268	mEq./hour	FinishedRunning
12	9407942	9407942	KCl	Day 13, 07:06	Day 13, 12:03	6.006060	mEq./hour	FinishedRunning
13	9182119	9182119	KCl	Day 13, 12:03	Day 13, 16:29	6.005904	mEq./hour	Stopped
14	9720623	9720623	KCl	Day 13, 18:15	Day 13, 23:15	6.000000	mEq./hour	FinishedRunning
15	2194578	2194578	KCl	Day 14, 15:28	Day 14, 18:47	6.000000	mEq./hour	FinishedRunning
16	7567525	7567525	KCl	Day 14, 18:47	Day 14, 19:01	6.000000	mEq./hour	Changed
17	7567525	4605649	KCl	Day 14, 19:01	Day 14, 23:04	4.007380	mEq./hour	Changed
18	7567525	5699592	KCl	Day 14, 23:04	Day 14, 23:18	5.871428	mEq./hour	FinishedRunning
19	8743715	8743715	KCl	Day 14, 23:18	Day 15, 02:28	5.905264	mEq./hour	FinishedRunning
20	4080709	4080709	KCl	Day 15, 02:28	Day 15, 05:44	5.969388	mEq./hour	FinishedRunning
21	4644782	4644782	KCl	Day 15, 05:44	Day 15, 08:57	5.906736	mEq./hour	FinishedRunning
22	741589	741589	KCl	Day 15, 08:57	Day 15, 12:08	5.905759	mEq./hour	FinishedRunning
23	6190220	6190220	KCl	Day 15, 12:08	Day 15, 15:17	5.904762	mEq./hour	FinishedRunning
24	1921010	1921010	KCl	Day 15, 15:17	Day 15, 18:34	5.908629	mEq./hour	FinishedRunning
25	3011912	3011912	KCl	Day 15, 18:34	Day 15, 21:46	5.906250	mEq./hour	FinishedRunning
26	1107318	1107318	KCl	Day 15, 21:46	Day 16, 01:01	5.907693	mEq./hour	FinishedRunning
27	609665	609665	KCl	Day 16, 01:01	Day 16, 04:18	5.908629	mEq./hour	FinishedRunning
28	4995198	4995198	KCl	Day 16, 04:18	Day 16, 07:36	5.903030	mEq./hour	FinishedRunning
29	4667423	4667423	KCl	Day 16, 07:36	Day 16, 10:54	5.903030	mEq./hour	FinishedRunning
30	4802077	4802077	KCl	Day 16, 10:54	Day 16, 14:12	5.903030	mEq./hour	FinishedRunning
31	8427007	8427007	KCl	Day 16, 14:12	Day 16, 16:04	5.905613	mEq./hour	Stopped

Normally linkorderid links together administrations which are consecutive but may have changes in rate, but from the above we can note that linkorderid seems to rarely group entries. Rows 8-10 and 16-18 are grouped (i.e. they are sequential administrations where the rate may or may not have changed), but many aren't *even though* they occur sequentially. We'd like to merge together sequential events to simplify the durations - and it appears we can greatly simplify this data by merging two rows if endtime(row-1) == starttime(row).

We can do this in three steps:

1. Create a binary flag that indicates when new "events" occur, where an "event" is defined as a continuous segment of administration, i.e. the binary flag is 1 if the row does not immediately follow the previous row, and 0 if the row does immediately follow the previous row
2. Aggregate this binary flag so each individual event is assigned a unique integer (i.e. create a partition over these events)
3. Create an integer to identify the last row in the event (so we can get useful information from this row)
4. Group the data based off the partition to result in a single starttime and endtime for each continguous medication administration

Now we'll go through the code for doing this step by step.

Step 1: create a binary flag for new events

```
with t1 as
(
select icustay_id
  , case when itemid = 227525 then 'Calcium' else 'KCl' end as label
  , starttime
  , endtime
  , case
      when lag(endtime) over (partition by icustay_id, itemid order by starttime, endtime) = starttime
        then 0
      else 1 end
    as new_event_flag
  , rate, rateuom
  , statusdescription
from inputevents_mv
where itemid in
(
  --227525,-- Calcium Gluconate (CRRT)
  227536 -- KCl (CRRT)
)
and statusdescription != 'Rewritten'
""" + query_where_clause + """
```

This selects data from INPUTEVENTS_MV for just KCl using a single patient specified by the query_where_clause (this is so it can act as an example - you can omit the single patient and it will work on all the data).

The key code block is here:

```
, case
    when lag(endtime) over (partition by icustay_id, itemid order by starttime, endtime) = starttime
      then 0
    else 1 end
  as new_event_flag
```

This creates a boolean flag which is 1 every time the current starttime is not equal to the previous endtime, i.e. it marks new "events". We can see it in action here:

In [17]:
```
print("Durations from INPUTEVENTS_MV, new events noted with time_partition...")
query = query_schema + """
with t1 as
(
select
  icustay_id
  , case when itemid = 227525 then 'Calcium' else 'KCl' end as label
  , starttime, endtime
  , lag(endtime) over (partition by icustay_id, itemid order by starttime, endtime) as endtime_lag
  , case
      when lag(endtime) over (partition by icustay_id, itemid order by starttime, endtime) = starttime
        then 0
      else 1 end
    as new_event_flag
  , rate, rateuom
  , statusdescription
from inputevents_mv
where itemid in
(
  --227525,-- Calcium Gluconate (CRRT)
  227536 -- KCl (CRRT)
```

```
)
and statusdescription != 'Rewritten'
""" + query_where_clause + """
)
select
  label
, starttime
, endtime
, endtime_lag
, new_event_flag
, rate, rateuom
, statusdescription
from t1
"""
ie = pd.read_sql_query(query,con)

display_df(ie)
```

Durations from INPUTEVENTS_MV, new events noted with time_partition...

	label	starttime	endtime	endtime_lag	new_event_flag	rate	rateuom	statusdescription
0	KCl	Day 11, 21:30	Day 12, 02:30	NaT	1	4.000000	mEq./hour	FinishedRunning
1	KCl	Day 11, 23:45	Day 12, 02:41	Day 12, 02:30	1	10.002273	mEq./hour	FinishedRunning
2	KCl	Day 12, 02:41	Day 12, 05:36	Day 12, 02:41	0	9.997713	mEq./hour	FinishedRunning
3	KCl	Day 12, 05:36	Day 12, 08:31	Day 12, 05:36	0	10.285715	mEq./hour	FinishedRunning
4	KCl	Day 12, 08:31	Day 12, 11:29	Day 12, 08:31	0	10.112360	mEq./hour	FinishedRunning
5	KCl	Day 12, 11:29	Day 12, 14:28	Day 12, 11:29	0	10.055866	mEq./hour	FinishedRunning
6	KCl	Day 12, 14:28	Day 12, 17:25	Day 12, 14:28	0	10.169492	mEq./hour	FinishedRunning
7	KCl	Day 12, 17:25	Day 12, 20:24	Day 12, 17:25	0	10.055866	mEq./hour	FinishedRunning
8	KCl	Day 12, 20:24	Day 12, 20:30	Day 12, 20:24	0	10.000000	mEq./hour	Paused
9	KCl	Day 12, 21:30	Day 12, 21:35	Day 12, 20:30	1	9.997634	mEq./hour	Changed
10	KCl	Day 12, 21:35	Day 13, 02:08	Day 12, 21:35	0	6.190549	mEq./hour	FinishedRunning
11	KCl	Day 13, 02:08	Day 13, 07:06	Day 13, 02:08	0	6.040268	mEq./hour	FinishedRunning
12	KCl	Day 13, 07:06	Day 13, 12:03	Day 13, 07:06	0	6.006060	mEq./hour	FinishedRunning
13	KCl	Day 13, 12:03	Day 13, 16:29	Day 13, 12:03	0	6.005904	mEq./hour	Stopped
14	KCl	Day 13, 18:15	Day 13, 23:15	Day 13, 16:29	1	6.000000	mEq./hour	FinishedRunning
15	KCl	Day 14, 15:28	Day 14, 18:47	Day 13, 23:15	1	6.000000	mEq./hour	FinishedRunning
16	KCl	Day 14, 18:47	Day 14, 19:01	Day 14, 18:47	0	6.000000	mEq./hour	Changed
17	KCl	Day 14, 19:01	Day 14, 23:04	Day 14, 19:01	0	4.007380	mEq./hour	Changed
18	KCl	Day 14, 23:04	Day 14, 23:18	Day 14, 23:04	0	5.871428	mEq./hour	FinishedRunning
19	KCl	Day 14, 23:18	Day 15, 02:28	Day 14, 23:18	0	5.905264	mEq./hour	FinishedRunning
20	KCl	Day 15, 02:28	Day 15, 05:44	Day 15, 02:28	0	5.969388	mEq./hour	FinishedRunning
21	KCl	Day 15, 05:44	Day 15, 08:57	Day 15, 05:44	0	5.906736	mEq./hour	FinishedRunning
22	KCl	Day 15, 08:57	Day 15, 12:08	Day 15, 08:57	0	5.905759	mEq./hour	FinishedRunning
23	KCl	Day 15, 12:08	Day 15, 15:17	Day 15, 12:08	0	5.904762	mEq./hour	FinishedRunning
24	KCl	Day 15, 15:17	Day 15, 18:34	Day 15, 15:17	0	5.908629	mEq./hour	FinishedRunning
25	KCl	Day 15, 18:34	Day 15, 21:46	Day 15, 18:34	0	5.906250	mEq./hour	FinishedRunning
26	KCl	Day 15, 21:46	Day 16, 01:01	Day 15, 21:46	0	5.907693	mEq./hour	FinishedRunning
27	KCl	Day 16, 01:01	Day 16, 04:18	Day 16, 01:01	0	5.908629	mEq./hour	FinishedRunning
28	KCl	Day 16, 04:18	Day 16, 07:36	Day 16, 04:18	0	5.903030	mEq./hour	FinishedRunning
29	KCl	Day 16, 07:36	Day 16, 10:54	Day 16, 07:36	0	5.903030	mEq./hour	FinishedRunning
30	KCl	Day 16, 10:54	Day 16, 14:12	Day 16, 10:54	0	5.903030	mEq./hour	FinishedRunning
31	KCl	Day 16, 14:12	Day 16, 16:04	Day 16, 14:12	0	5.905613	mEq./hour	Stopped

Note we have added the endtime_lag column to give a clearer idea of how the query is working. We can see the first row starts with new_event_flag = 1 since endtime_lag is null. Next, the endtime_lag != starttime, so new_event_flag is again = 1.

Finally, for row 2 (marked by **2** on the far left), the endtime_lag == starttime - and so new_event_flag is 0. This continues all the way until row **9**, where we can again see endtime_lag != starttime. Note that the statusdescription on row **8** even informs us why: it states that the administration has been "Paused". This is why we mentioned earlier that we were interested in the last row from an event.

Step 2: create a binary flag for new events

With SQL, in order to aggregate groups of rows, we need a *partition*. That is, we need some key (usually an integer) which is unique for that set of rows. Once we have this unique key, we can do all the standard SQL aggregations like max(), min(), and so on (note: SQL "window" functions operate on the same principle, except you define the partition explicitly from a combination of columns).

With this in mind, our next step is to use this flag to create a unique integer for each set of rows we'd like grouped. Since we'd like to group new events together, we can run a cumulative sum along new_event_flag: every time a new event occurs, the integer will increase and consequently that event will all have the same unique key. The code to do this is:

SUM(new_event_flag) OVER (partition **by** icustay_id, label **order by** starttime, endtime) **as** time_partition

Let's see this in action:

In [18]:
```
print("Durations from INPUTEVENTS for one patient with KCl...")
query = query_schema + """
with t1 as
(
select icustay_id
  , case when itemid = 227525 then 'Calcium' else 'KCl' end as label
  , starttime
  , endtime
  , case
      when lag(endtime) over (partition by icustay_id, itemid order by starttime, endtime) = starttime
        then 0
      else 1 end
    as new_event_flag
  , rate, rateuom
  , statusdescription
from inputevents_mv
where itemid in
(
  –227525,– Calcium Gluconate (CRRT)
  227536 – KCl (CRRT)
)
and statusdescription != 'Rewritten'
""" + query_where_clause + """
)
, t2 as
(
    select
    icustay_id
    , label
    , starttime, endtime
    , new_event_flag
    , SUM(new_event_flag) OVER (partition by icustay_id, label order by starttime, endtime) as time_partition
    , rate, rateuom, statusdescription
    from t1
)
select
      label
    , starttime
    , endtime
    , new_event_flag
    , time_partition
    , rate, rateuom, statusdescription

from t2
order by starttime, endtime
"""
ie = pd.read_sql_query(query,con)

display_df(ie)
```

Durations from INPUTEVENTS for one patient with KCl...

	label	starttime	endtime	new_event_flag	time_partition	rate	rateuom	statusdescription
0	KCl	Day 11, 21:30	Day 12, 02:30	1	1	4.000000	mEq./hour	FinishedRunning
1	KCl	Day 11, 23:45	Day 12, 02:41	1	2	10.002273	mEq./hour	FinishedRunning
2	KCl	Day 12, 02:41	Day 12, 05:36	0	2	9.997713	mEq./hour	FinishedRunning
3	KCl	Day 12, 05:36	Day 12, 08:31	0	2	10.285715	mEq./hour	FinishedRunning
4	KCl	Day 12, 08:31	Day 12, 11:29	0	2	10.112360	mEq./hour	FinishedRunning
5	KCl	Day 12, 11:29	Day 12, 14:28	0	2	10.055866	mEq./hour	FinishedRunning
6	KCl	Day 12, 14:28	Day 12, 17:25	0	2	10.169492	mEq./hour	FinishedRunning
7	KCl	Day 12, 17:25	Day 12, 20:24	0	2	10.055866	mEq./hour	FinishedRunning
8	KCl	Day 12, 20:24	Day 12, 20:30	0	2	10.000000	mEq./hour	Paused
9	KCl	Day 12, 21:30	Day 12, 21:35	1	3	9.997634	mEq./hour	Changed

10	KCl	Day 12, 21:35	Day 13, 02:08	0	3	6.190549	mEq./hour	FinishedRunning
11	KCl	Day 13, 02:08	Day 13, 07:06	0	3	6.040268	mEq./hour	FinishedRunning
12	KCl	Day 13, 07:06	Day 13, 12:03	0	3	6.006060	mEq./hour	FinishedRunning
13	KCl	Day 13, 12:03	Day 13, 16:29	0	3	6.005904	mEq./hour	Stopped
14	KCl	Day 13, 18:15	Day 13, 23:15	1	4	6.000000	mEq./hour	FinishedRunning
15	KCl	Day 14, 15:28	Day 14, 18:47	1	5	6.000000	mEq./hour	FinishedRunning
16	KCl	Day 14, 18:47	Day 14, 19:01	0	5	6.000000	mEq./hour	Changed
17	KCl	Day 14, 19:01	Day 14, 23:04	0	5	4.007380	mEq./hour	Changed
18	KCl	Day 14, 23:04	Day 14, 23:18	0	5	5.871428	mEq./hour	FinishedRunning
19	KCl	Day 14, 23:18	Day 15, 02:28	0	5	5.905264	mEq./hour	FinishedRunning
20	KCl	Day 15, 02:28	Day 15, 05:44	0	5	5.969388	mEq./hour	FinishedRunning
21	KCl	Day 15, 05:44	Day 15, 08:57	0	5	5.906736	mEq./hour	FinishedRunning
22	KCl	Day 15, 08:57	Day 15, 12:08	0	5	5.905759	mEq./hour	FinishedRunning
23	KCl	Day 15, 12:08	Day 15, 15:17	0	5	5.904762	mEq./hour	FinishedRunning
24	KCl	Day 15, 15:17	Day 15, 18:34	0	5	5.908629	mEq./hour	FinishedRunning
25	KCl	Day 15, 18:34	Day 15, 21:46	0	5	5.906250	mEq./hour	FinishedRunning
26	KCl	Day 15, 21:46	Day 16, 01:01	0	5	5.907693	mEq./hour	FinishedRunning
27	KCl	Day 16, 01:01	Day 16, 04:18	0	5	5.908629	mEq./hour	FinishedRunning
28	KCl	Day 16, 04:18	Day 16, 07:36	0	5	5.903030	mEq./hour	FinishedRunning
29	KCl	Day 16, 07:36	Day 16, 10:54	0	5	5.903030	mEq./hour	FinishedRunning
30	KCl	Day 16, 10:54	Day 16, 14:12	0	5	5.903030	mEq./hour	FinishedRunning
31	KCl	Day 16, 14:12	Day 16, 16:04	0	5	5.905613	mEq./hour	Stopped

The above (hopefully) makes it clear how a unique partition for each continuous segment of KCl administration can be delineated by cumulatively summing new_event_flag to create time_partition.

Step 3: create an integer to mark the last row of an event

From above, it appears as though the *last* statusdescription would provide us useful debugging information as to why the administration event stopped - so we have another inline view where we create an integer which is 1 for the last statusdescription.

In [19]:
```
print("Durations from INPUTEVENTS for one patient with KCl...")
query = query_schema + """
with t1 as
(
select icustay_id
  , case when itemid = 227525 then 'Calcium' else 'KCl' end as label
  , starttime
  , endtime
  , case
      when lag(endtime) over (partition by icustay_id, itemid order by starttime, endtime) = starttime
        then 0
      else 1 end
    as new_event_flag
  , rate, rateuom
  , statusdescription
from inputevents_mv
where itemid in
(
  –227525,– Calcium Gluconate (CRRT)
  227536 – KCl (CRRT)
)
and statusdescription != 'Rewritten'
""" + query_where_clause + """
)
, t2 as
(
    select
    icustay_id
    , label
    , starttime, endtime
    , SUM(new_event_flag) OVER (partition by icustay_id, label order by starttime, endtime) as time_partition
    , rate, rateuom, statusdescription
    from t1
)
, t3 as
(
select
```

```
select
    icustay_id
    , label
    , starttime, endtime
    , time_partition
    , rate, rateuom, statusdescription
    , ROW_NUMBER() over (PARTITION BY icustay_id, label, time_partition order by starttime desc, endtime desc) as lastrow
from t2
)
select
label
, starttime
, endtime
, time_partition
, rate, rateuom
, statusdescription
, lastrow
 from t3
order by starttime, endtime
"""
ie = pd.read_sql_query(query,con)

display_df(ie)
```

Durations from INPUTEVENTS for one patient with KCl...

	label	starttime	endtime	time_partition	rate	rateuom	statusdescription	lastrow
0	KCl	Day 11, 21:30	Day 12, 02:30	1	4.000000	mEq./hour	FinishedRunning	1
1	KCl	Day 11, 23:45	Day 12, 02:41	2	10.002273	mEq./hour	FinishedRunning	8
2	KCl	Day 12, 02:41	Day 12, 05:36	2	9.997713	mEq./hour	FinishedRunning	7
3	KCl	Day 12, 05:36	Day 12, 08:31	2	10.285715	mEq./hour	FinishedRunning	6
4	KCl	Day 12, 08:31	Day 12, 11:29	2	10.112360	mEq./hour	FinishedRunning	5
5	KCl	Day 12, 11:29	Day 12, 14:28	2	10.055866	mEq./hour	FinishedRunning	4
6	KCl	Day 12, 14:28	Day 12, 17:25	2	10.169492	mEq./hour	FinishedRunning	3
7	KCl	Day 12, 17:25	Day 12, 20:24	2	10.055866	mEq./hour	FinishedRunning	2
8	KCl	Day 12, 20:24	Day 12, 20:30	2	10.000000	mEq./hour	Paused	1
9	KCl	Day 12, 21:30	Day 12, 21:35	3	9.997634	mEq./hour	Changed	5
10	KCl	Day 12, 21:35	Day 13, 02:08	3	6.190549	mEq./hour	FinishedRunning	4
11	KCl	Day 13, 02:08	Day 13, 07:06	3	6.040268	mEq./hour	FinishedRunning	3
12	KCl	Day 13, 07:06	Day 13, 12:03	3	6.006060	mEq./hour	FinishedRunning	2
13	KCl	Day 13, 12:03	Day 13, 16:29	3	6.005904	mEq./hour	Stopped	1
14	KCl	Day 13, 18:15	Day 13, 23:15	4	6.000000	mEq./hour	FinishedRunning	1
15	KCl	Day 14, 15:28	Day 14, 18:47	5	6.000000	mEq./hour	FinishedRunning	17
16	KCl	Day 14, 18:47	Day 14, 19:01	5	6.000000	mEq./hour	Changed	16
17	KCl	Day 14, 19:01	Day 14, 23:04	5	4.007380	mEq./hour	Changed	15
18	KCl	Day 14, 23:04	Day 14, 23:18	5	5.871428	mEq./hour	FinishedRunning	14
19	KCl	Day 14, 23:18	Day 15, 02:28	5	5.905264	mEq./hour	FinishedRunning	13
20	KCl	Day 15, 02:28	Day 15, 05:44	5	5.969388	mEq./hour	FinishedRunning	12
21	KCl	Day 15, 05:44	Day 15, 08:57	5	5.906736	mEq./hour	FinishedRunning	11
22	KCl	Day 15, 08:57	Day 15, 12:08	5	5.905759	mEq./hour	FinishedRunning	10
23	KCl	Day 15, 12:08	Day 15, 15:17	5	5.904762	mEq./hour	FinishedRunning	9
24	KCl	Day 15, 15:17	Day 15, 18:34	5	5.908629	mEq./hour	FinishedRunning	8
25	KCl	Day 15, 18:34	Day 15, 21:46	5	5.906250	mEq./hour	FinishedRunning	7
26	KCl	Day 15, 21:46	Day 16, 01:01	5	5.907693	mEq./hour	FinishedRunning	6
27	KCl	Day 16, 01:01	Day 16, 04:18	5	5.908629	mEq./hour	FinishedRunning	5
28	KCl	Day 16, 04:18	Day 16, 07:36	5	5.903030	mEq./hour	FinishedRunning	4
29	KCl	Day 16, 07:36	Day 16, 10:54	5	5.903030	mEq./hour	FinishedRunning	3
30	KCl	Day 16, 10:54	Day 16, 14:12	5	5.903030	mEq./hour	FinishedRunning	2
31	KCl	Day 16, 14:12	Day 16, 16:04	5	5.905613	mEq./hour	Stopped	1

Step 4: aggregate to merge together contiguous start/end times

Now we aggregate the starttime and endtime together by grouping by time_partition, as follows:

- we want the first starttime, so we use min(starttime)
- we want the last endtime, so we use max(endtime)
- we want the statusdescription at the last row, so we aggregate a column where all rows except the last are null

To give more detail on the last step, let's look at the SQL code:

, **min**(**case when** lastrow = 1 **then** statusdescription **else null end**) **as** statusdescription

Aggregate functions ignore null values, so if we set the column to null for all but lastrow = 1, then the aggregate function is guaranteed to only return the value at lastrow = 1. The use of aggregate function could be either min() or max() - since it only effectively operates on a single value.

Tying it all together, we have the final query:

In [20]:
```
print("Durations from INPUTEVENTS for one patient with KCl...")
query = query_schema + """
with t1 as
(
select icustay_id
  , case when itemid = 227525 then 'Calcium' else 'KCl' end as label
  , starttime
  , endtime
  , case
      when lag(endtime) over (partition by icustay_id, itemid order by starttime, endtime) = starttime
        then 0
      else 1 end
    as new_event_flag
  , rate, rateuom
  , statusdescription
from inputevents_mv
where itemid in
(
  227525,-- Calcium Gluconate (CRRT)
  227536 -- KCl (CRRT)
)
and statusdescription != 'Rewritten'
""" + query_where_clause + """
)
, t2 as
(
    select
    icustay_id
    , label
    , starttime, endtime
    , SUM(new_event_flag) OVER (partition by icustay_id, label order by starttime, endtime) as time_partition
    , rate, rateuom, statusdescription
    from t1
)
, t3 as
(
select
    icustay_id
    , label
    , starttime, endtime
    , time_partition
    , rate, rateuom, statusdescription
    , ROW_NUMBER() over (PARTITION BY icustay_id, label, time_partition order by starttime desc, endtime desc) as lastrow
from t2
)
select
  label
  --, time_partition
  , min(starttime) AS starttime
  , max(endtime) AS endtime
  , min(rate) AS rate_min
  , max(rate) AS rate_max
  , min(rateuom) AS rateuom
  , min(case when lastrow = 1 then statusdescription else null end) as statusdescription
from t3
group by icustay_id, label, time_partition
order by starttime, endtime
"""
ie = pd.read_sql_query(query,con)

display_df(ie)
```

Durations from INPUTEVENTS for one patient with KCl...

	label	starttime	endtime	rate_min	rate_max	rateuom	statusdescription
0	KCl	Day 11, 21:30	Day 12, 02:30	4.000000	4.000000	mEq./hour	FinishedRunning
1	KCl	Day 11, 23:45	Day 12, 20:30	9.997713	10.285715	mEq./hour	Paused

2	Calcium	Day 11, 23:45	Day 12, 20:30	1.201625	2.002708	grams/hour	Paused
3	Calcium	Day 12, 21:30	Day 13, 15:54	1.206690	1.805171	grams/hour	FinishedRunning
4	KCl	Day 12, 21:30	Day 13, 16:29	6.005904	9.997634	mEq./hour	Stopped
5	KCl	Day 13, 18:15	Day 13, 23:15	6.000000	6.000000	mEq./hour	FinishedRunning
6	Calcium	Day 13, 18:15	Day 13, 23:15	1.602136	1.602136	grams/hour	Paused
7	KCl	Day 14, 15:28	Day 16, 16:04	4.007380	6.000000	mEq./hour	Stopped
8	Calcium	Day 14, 15:28	Day 16, 16:05	1.196013	1.990426	grams/hour	Stopped

The above looks good - so we save the query to query_inputevents without the clause that isolates the data to one patient.

In [21]:
```
query_inputevents = query_schema + """
with t1 as
(
select icustay_id
  , case when itemid = 227525 then 'Calcium' else 'KCl' end as label
  , starttime
  , endtime
  , case
      when lag(endtime) over (partition by icustay_id, itemid order by starttime, endtime) = starttime
        then 0
      else 1 end
    as new_event_flag
  , rate, rateuom
  , statusdescription
from inputevents_mv
where itemid in
(
  227525,-- Calcium Gluconate (CRRT)
  227536 -- KCl (CRRT)
)
and statusdescription != 'Rewritten'
)
, t2 as
(
    select
    icustay_id
    , label
    , starttime, endtime
    , SUM(new_event_flag) OVER (partition by icustay_id, label order by starttime, endtime) as time_partition
    , rate, rateuom, statusdescription
    from t1
)
, t3 as
(
select
    icustay_id
    , label
    , starttime, endtime
    , time_partition
    , rate, rateuom, statusdescription
    , ROW_NUMBER() over (PARTITION BY icustay_id, label, time_partition order by starttime desc, endtime desc) as lastrow
from t2
)
select
    icustay_id
    , time_partition as num
    , min(starttime) AS starttime
    , max(endtime) AS endtime
    , label
    --, min(rate) AS rate_min
    --, max(rate) AS rate_max
    --, min(rateuom) AS rateuom
    --, min(case when lastrow = 1 then statusdescription else null end) as statusdescription
from t3
group by icustay_id, label, time_partition
order by starttime, endtime
"""
```

Conclusion

We now have a good method of combining contiguous events from INPUTEVENTS_MV. Note that this is *usually* not required, as the linkorderid is meant to partition these events for us. For example, lets look at a very common sedative agent used in the ICU, propofol:

In [22]:
```
print("Durations from INPUTEVENTS for one patient given propofol...")
query = query_schema + """
with t1 as
(
```

```
(
select icustay_id
  , di.label
  , mv.linkorderid, mv.orderid
  , starttime
  , endtime
  , rate, rateuom
  , amount, amountuom
from inputevents_mv mv
inner join d_items di
on mv.itemid = di.itemid
and statusdescription != 'Rewritten'
""" + query_where_clause + """
and mv.itemid = 222168
)
select
    label
  , linkorderid, orderid
  , starttime
  , endtime
  , rate, rateuom
  , amount, amountuom
from t1
order by starttime, endtime
"""
ie = pd.read_sql_query(query,con)

display_df(ie)
```

Durations from INPUTEVENTS for one patient given propofol...

	label	linkorderid	orderid	starttime	endtime	rate	rateuom	amount	amountuom
0	Propofol	1405816	1405816	Day 09, 18:29	Day 10, 00:14	50.002502	mcg/kg/min	17.250863	mg
1	Propofol	1405816	2101314	Day 10, 01:01	Day 10, 01:05	50.002502	mcg/kg/min	0.200010	mg
2	Propofol	1405816	7312240	Day 10, 01:05	Day 10, 08:05	40.001221	mcg/kg/min	16.800513	mg
3	Propofol	1405816	7169415	Day 10, 08:15	Day 10, 12:00	40.001221	mcg/kg/min	9.000275	mg
4	Propofol	1405816	5852722	Day 10, 12:05	Day 10, 12:40	40.001221	mcg/kg/min	1.400043	mg
5	Propofol	1405816	3365285	Day 10, 12:40	Day 10, 14:00	20.000627	mcg/kg/min	1.600050	mg
6	Propofol	522225	522225	Day 10, 14:00	Day 10, 14:01		None	10.000001	mg
7	Propofol	1405816	5245063	Day 10, 14:00	Day 10, 14:07	40.001254	mcg/kg/min	0.280009	mg
8	Propofol	2703553	2703553	Day 10, 14:05	Day 10, 14:06		None	10.000001	mg
9	Propofol	1405816	6687581	Day 10, 14:07	Day 11, 08:45	30.001253	mcg/kg/min	33.541401	mg
10	Propofol	4912696	4912696	Day 10, 16:10	Day 10, 16:11		None	10.000001	mg
11	Propofol	3838086	3838086	Day 10, 16:55	Day 10, 16:56		None	10.000001	mg
12	Propofol	5665808	5665808	Day 11, 01:51	Day 11, 01:52		None	10.000001	mg
13	Propofol	1405816	3755617	Day 11, 09:10	Day 11, 13:36	30.001253	mcg/kg/min	7.980333	mg

Here we see that linkorderid nicely delineates contiguous events without us having to put in the effort of above. It also separates *distinct* administrations. Above, at row **6**, we can see a "1 minute" delivery of propofol. This is how MetaVision tables (those which end in _mv) mark "instant" events - in the case of drug delivery, these are boluses of drugs administered to the patient.

When using this data, we can group like events on a partition (as we did above), but we don't have to create the partition: it already exists with linkorderid.

In [23]:
```
print("Grouped durations from INPUTEVENTS for one patient given propofol...")
query = query_schema + """
with t1 as
(
select icustay_id
  , di.itemid, di.label
  , mv.linkorderid, mv.orderid
  , starttime
  , endtime
  , amount, amountuom
  , rate, rateuom
from inputevents_mv mv
inner join d_items di
on mv.itemid = di.itemid
and statusdescription != 'Rewritten'
""" + query_where_clause + """
and mv.itemid = 222168
)
select icustay_id
  , label
```

```
 , linkorderid
 , min(starttime) as starttime
 , max(endtime) as endtime
 , min(rate) as rate_min
 , max(rate) as rate_max
 , max(rateuom) as rateuom
 , min(amount) as amount_min
 , max(amount) as amount_max
 , max(amountuom) as amountuom
from t1
group by icustay_id, itemid, label, linkorderid
order by starttime, endtime
"""
ie = pd.read_sql_query(query,con)

display_df(ie)
```

Grouped durations from INPUTEVENTS for one patient given propofol...

	label	linkorderid	starttime	endtime	rate_min	rate_max	rateuom	amount_min	amount_max	amountu
0	Propofol	1405816	Day 09, 18:29	Day 11, 13:36	20.000627	50.002502	mcg/kg/min	0.200010	33.541401	mg
1	Propofol	522225	Day 10, 14:00	Day 10, 14:01			None	10.000001	10.000001	mg
2	Propofol	2703553	Day 10, 14:05	Day 10, 14:06			None	10.000001	10.000001	mg
3	Propofol	4912696	Day 10, 16:10	Day 10, 16:11			None	10.000001	10.000001	mg
4	Propofol	3838086	Day 10, 16:55	Day 10, 16:56			None	10.000001	10.000001	mg
5	Propofol	5665808	Day 11, 01:51	Day 11, 01:52			None	10.000001	10.000001	mg

It's also worth noting that bolus administrations *do not have a rate*. They only have an amount.

2 Convert CHARTEVENTS into durations

In [24]:

```
# convert CHARTEVENTS into durations
# NOTE: we only look at a single patient as an exemplar
print("Durations from CHARTEVENTS...")
query = query_schema + """
with crrt_settings as
(
select ce.icustay_id, ce.charttime
, max(
    case
      when ce.itemid in
      (
        224149, – Access Pressure
        224144, – Blood Flow (ml/min)
        228004, – Citrate (ACD-A)
        225183, – Current Goal
        225977, – Dialysate Fluid
        224154, – Dialysate Rate
        224151, – Effluent Pressure
        224150, – Filter Pressure
        225958, – Heparin Concentration (units/mL)
        224145, – Heparin Dose (per hour)
        224191, – Hourly Patient Fluid Removal
        228005, – PBP (Prefilter) Replacement Rate
        228006, – Post Filter Replacement Rate
        225976, – Replacement Fluid
        224153, – Replacement Rate
        224152, – Return Pressure
        226457  – Ultrafiltrate Output
      ) then 1
    else 0 end)
    as RRT
– Below indicates that a new instance of CRRT has started
, max(
  case
    – System Integrity
    when ce.itemid = 224146 and value in ('New Filter','Reinitiated')
      then 1
  else 0
 end ) as RRT_start
– Below indicates that the current instance of CRRT has ended
```

```
, max(
  case
    – System Integrity
    when ce.itemid = 224146 and value in ('Discontinued','Recirculating')
      then 1
    when ce.itemid = 225956
      then 1
  else 0
 end ) as RRT_end
from chartevents ce
where ce.itemid in
(
  – MetaVision ITEMIDs
  – Below require special handling
  224146, – System Integrity
  225956,  – Reason for CRRT Filter Change

  – Below are settings which indicate CRRT is started/continuing
  224149, – Access Pressure
  224144, – Blood Flow (ml/min)
  228004, – Citrate (ACD-A)
  225183, – Current Goal
  225977, – Dialysate Fluid
  224154, – Dialysate Rate
  224151, – Effluent Pressure
  224150, – Filter Pressure
  225958, – Heparin Concentration (units/mL)
  224145, – Heparin Dose (per hour)
  224191, – Hourly Patient Fluid Removal
  228005, – PBP (Prefilter) Replacement Rate
  228006, – Post Filter Replacement Rate
  225976, – Replacement Fluid
  224153, – Replacement Rate
  224152, – Return Pressure
  226457  – Ultrafiltrate Output
)
and ce.value is not null
""" + query_where_clause + """
group by icustay_id, charttime
)

– create the durations for each CRRT instance
select icustay_id
  , ROW_NUMBER() over (partition by icustay_id order by num) as num
  , min(charttime) as starttime
  , max(charttime) as endtime
from
(
  select vd1.*
  – create a cumulative sum of the instances of new CRRT
  – this results in a monotonically increasing integer assigned to each CRRT
  , case when RRT_start = 1 or RRT=1 or RRT_end = 1 then
      SUM( NewCRRT )
      OVER ( partition by icustay_id order by charttime )
    else null end
    as num
  — now we convert CHARTTIME of CRRT settings into durations
  from ( – vd1
      select
          icustay_id
          – this carries over the previous charttime
          , case
              when RRT=1 then
                LAG(CHARTTIME, 1) OVER (partition by icustay_id, RRT order by charttime)
              else null
            end as charttime_lag
          , charttime
          , RRT
          , RRT_start
          , RRT_end
          – calculate the time since the last event
          , case
              – non-null iff the current observation indicates settings are present
              when RRT=1 then
                CHARTTIME -
                (
                  LAG(CHARTTIME, 1) OVER
                  (
                    partition by icustay_id, RRT
                    order by charttime
                  )
                )
              else null
            end as CRRT_duration

          – now we determine if the current event is a new instantiation
```

```
        , case
            when RRT_start = 1
              then 1
          – if there is an end flag, we mark any subsequent event as new
            when RRT_end = 1
              – note the end is *not* a new event, the *subsequent* row is
              – so here we output 0
              then 0
            when
              LAG(RRT_end,1)
              OVER
              (
              partition by icustay_id, case when RRT=1 or RRT_end=1 then 1 else 0 end
              order by charttime
              ) = 1
                then 1
              – if there is less than 2 hours between CRRT settings, we do not treat this as a new CRRT event
            when (CHARTTIME - (LAG(CHARTTIME, 1)
            OVER
            (
              partition by icustay_id, case when RRT=1 or RRT_end=1 then 1 else 0 end
              order by charttime
            ))) <= interval '2' hour
              then 0
          else 1
        end as NewCRRT
      – use the temp table with only settings from chartevents
      FROM crrt_settings
  ) AS vd1
  – now we can isolate to just rows with settings
  – (before we had rows with start/end flags)
  – this removes any null values for NewCRRT
  where
    RRT_start = 1 or RRT = 1 or RRT_end = 1
) AS vd2
group by icustay_id, num
having min(charttime) != max(charttime)
order by icustay_id, num
"""
ce = pd.read_sql_query(query,con)

display_df(ce)
```

Durations from CHARTEVENTS...

	num	starttime	endtime
0	1	Day 11, 23:43	Day 12, 20:00
1	2	Day 12, 22:00	Day 13, 16:30
2	3	Day 13, 18:15	Day 13, 23:00
3	4	Day 14, 15:27	Day 16, 16:00

In [25]:

```
# happy with the above query - repeat it without the isolation to a single ICUSTAY_ID
query_chartevents = query_schema + """
with crrt_settings as
(
select ce.icustay_id, ce.charttime
, max(
    case
      when ce.itemid in
      (
        224149, – Access Pressure
        224144, – Blood Flow (ml/min)
        228004, – Citrate (ACD-A)
        225183, – Current Goal
        225977, – Dialysate Fluid
        224154, – Dialysate Rate
        224151, – Effluent Pressure
        224150, – Filter Pressure
        225958, – Heparin Concentration (units/mL)
        224145, – Heparin Dose (per hour)
        224191, – Hourly Patient Fluid Removal
        228005, – PBP (Prefilter) Replacement Rate
        228006, – Post Filter Replacement Rate
        225976, – Replacement Fluid
        224153, – Replacement Rate
        224152, – Return Pressure
        226457  – Ultrafiltrate Output
      ) then 1
    else 0 end)
    as RRT
– Below indicates that a new instance of CRRT has started
, max(
```

```
  case
    – System Integrity
    when ce.itemid = 224146 and value in ('New Filter','Reinitiated')
      then 1
  else 0
 end ) as RRT_start
– Below indicates that the current instance of CRRT has ended
, max(
  case
    – System Integrity
    when ce.itemid = 224146 and value in ('Discontinued','Recirculating')
      then 1
    when ce.itemid = 225956
      then 1
  else 0
 end ) as RRT_end
from chartevents ce
where ce.itemid in
(
  – MetaVision ITEMIDs
  – Below require special handling
  224146, – System Integrity
  225956,  – Reason for CRRT Filter Change

  – Below are settings which indicate CRRT is started/continuing
  224149, – Access Pressure
  224144, – Blood Flow (ml/min)
  228004, – Citrate (ACD-A)
  225183, – Current Goal
  225977, – Dialysate Fluid
  224154, – Dialysate Rate
  224151, – Effluent Pressure
  224150, – Filter Pressure
  225958, – Heparin Concentration (units/mL)
  224145, – Heparin Dose (per hour)
  224191, – Hourly Patient Fluid Removal
  228005, – PBP (Prefilter) Replacement Rate
  228006, – Post Filter Replacement Rate
  225976, – Replacement Fluid
  224153, – Replacement Rate
  224152, – Return Pressure
  226457  – Ultrafiltrate Output
)
and ce.value is not null
group by icustay_id, charttime
)

– create the durations for each CRRT instance
select icustay_id
  , ROW_NUMBER() over (partition by icustay_id order by num) as num
  , min(charttime) as starttime
  , max(charttime) as endtime
from
(
  select vd1.*
  – create a cumulative sum of the instances of new CRRT
  – this results in a monotonically increasing integer assigned to each CRRT
  , case when RRT_start = 1 or RRT=1 or RRT_end = 1 then
      SUM( NewCRRT )
      OVER ( partition by icustay_id order by charttime )
    else null end
    as num
  — now we convert CHARTTIME of CRRT settings into durations
  from ( – vd1
      select
          icustay_id
          – this carries over the previous charttime
          , case
              when RRT=1 then
                LAG(CHARTTIME, 1) OVER (partition by icustay_id, RRT order by charttime)
              else null
            end as charttime_lag
          , charttime
          , RRT
          , RRT_start
          , RRT_end
          – calculate the time since the last event
          , case
              – non-null iff the current observation indicates settings are present
              when RRT=1 then
                CHARTTIME -
                (
                  LAG(CHARTTIME, 1) OVER
                  (
                    partition by icustay_id, RRT
                    order by charttime
```

```
            )
          )
        else null
      end as CRRT_duration

    -- now we determine if the current event is a new instantiation
    , case
        when RRT_start = 1
          then 1
      -- if there is an end flag, we mark any subsequent event as new
        when RRT_end = 1
          -- note the end is *not* a new event, the *subsequent* row is
          -- so here we output 0
          then 0
        when
          LAG(RRT_end,1)
          OVER
          (
          partition by icustay_id, case when RRT=1 or RRT_end=1 then 1 else 0 end
          order by charttime
          ) = 1
            then 1
          -- if there is less than 2 hours between CRRT settings, we do not treat this as a new CRRT event
        when (CHARTTIME - (LAG(CHARTTIME, 1)
        OVER
        (
          partition by icustay_id, case when RRT=1 or RRT_end=1 then 1 else 0 end
          order by charttime
        ))) <= interval '2' hour
          then 0
      else 1
    end as NewCRRT
  -- use the temp table with only settings from chartevents
  FROM crrt_settings
) AS vd1
-- now we can isolate to just rows with settings
-- (before we had rows with start/end flags)
-- this removes any null values for NewCRRT
where
  RRT_start = 1 or RRT = 1 or RRT_end = 1
) AS vd2
group by icustay_id, num
having min(charttime) != max(charttime)
order by icustay_id, num
"""
```

이전 INP~ + CHAR~ 두개에서 가져온 duration을 비교하고 통합

③ Extract durations from PROCEDUREEVENTS_MV

PROCEDUREEVENTS_MV contains entries for dialysis. As a reminder from the above, we picked the following itemid:

- 225802 -- Dialysis - CRRT
- 225803 -- Dialysis - CVVHD
- 225809 -- Dialysis - CVVHDF
- 225955 -- Dialysis - SCUF

Extracting data for these entries is straightforward. Each instance of CRRT is documented with a single starttime and a single stoptime, with no need to merge together different rows.

In [26]:
```
# extract the durations from PROCEDUREEVENTS_MV
# NOTE: we only look at a single patient as an exemplar
print("Durations from PROCEDUREEVENTS_MV...")
query = query_schema + """
select icustay_id
  , ROW_NUMBER() over (partition by icustay_id order by starttime, endtime) as num
  , starttime, endtime
from procedureevents_mv
where itemid in
(
    225802 -- Dialysis - CRRT
  , 225803 -- Dialysis - CVVHD
  , 225809 -- Dialysis - CVVHDF
  , 225955 -- Dialysis - SCUF
)
""" + query_where_clause + """
order by icustay_id, num
"""
pe = pd.read_sql_query(query,con)

display_df(pe)
```

Durations from PROCEDUREEVENTS_MV...

	num	starttime	endtime

0	1	Day 11, 23:45	Day 12, 20:30
1	2	Day 12, 21:30	Day 13, 23:15
2	3	Day 14, 15:27	Day 16, 16:02

Note that the above documentation is quite dilligent: the entry pauses between the first and second row for 1 hour representing an actual pause in the administration of CRRT.

In [27]:
```
# happy with above query
query_procedureevents = query_schema + """
select icustay_id
  , ROW_NUMBER() over (partition by icustay_id order by starttime, endtime) as num
  , starttime, endtime
from procedureevents_mv
where itemid in
(
    225802 – Dialysis - CRRT
  , 225803 – Dialysis - CVVHD
  , 225809 – Dialysis - CVVHDF
  , 225955 – Dialysis - SCUF
)
order by icustay_id, num
"""
```

Roundup: data from INPUTEVENTS_MV, CHARTEVENTS, and PROCEDUREEVENTS_MV

In [ ]:
```
print("Durations from INPUTEVENTS...")
ie = pd.read_sql_query(query_inputevents,con)

print("Durations from CHARTEVENTS...")
ce = pd.read_sql_query(query_chartevents,con)

print("Durations from PROCEDUREEVENTS...")
pe = pd.read_sql_query(query_procedureevents,con)
```

④ Merge for a final durations table for MetaVision

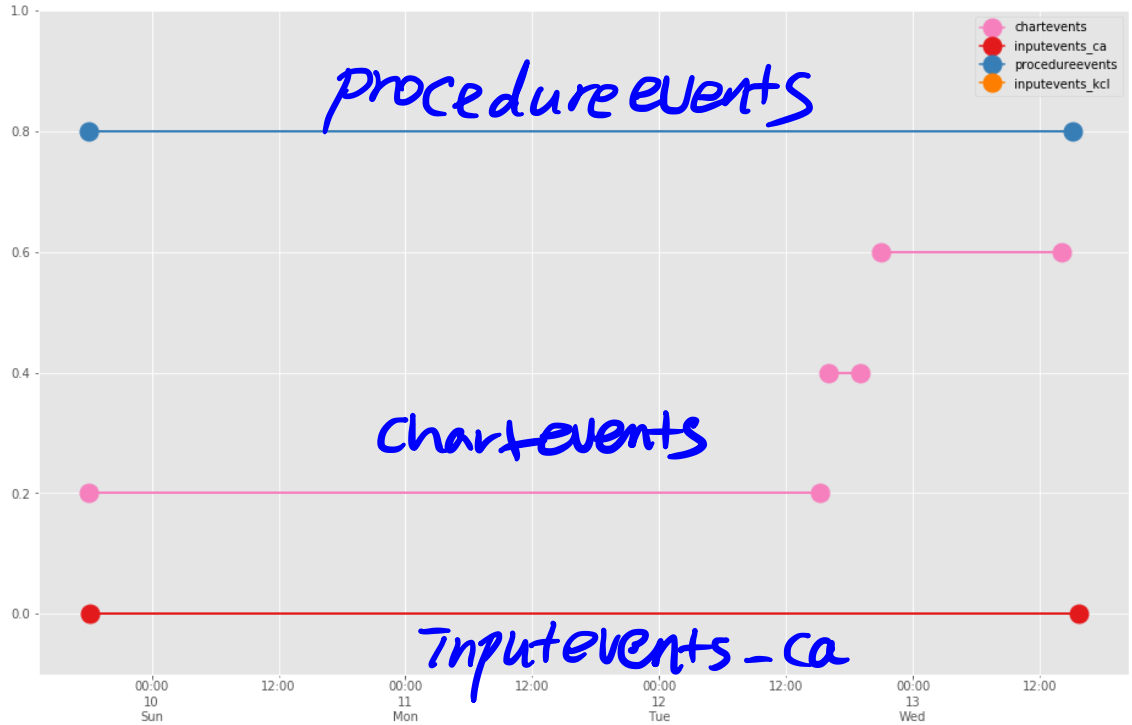
Compare durations

We now need to merge together the above durations into a single, master set of CRRT administrations.

In [38]:
```
# how many PROCEDUREEVENTS_MV dialysis events encapsulate CHARTEVENTS/INPUTEVENTS_MV?
# vice-versa?
iid = 205508

# compare the above durations
ce['source'] = 'chartevents'
ie['source'] = 'inputevents_kcl'
ie.loc[ie['label']=='Calcium','source'] = 'inputevents_ca'
pe['source'] = 'procedureevents'
df = pd.concat([ie[['icustay_id','num','starttime','endtime','source']], ce, pe])
idxDisplay = df['icustay_id'] == iid
display_df(df.loc[idxDisplay, :])

# 2) how many have no overlap whatsoever?


col_dict = {'chartevents': [247,129,191],
            'inputevents_kcl': [255,127,0],
            'inputevents_ca': [228,26,28],
            'procedureevents': [55,126,184]}

for c in col_dict:
    col_dict[c] = [x/256.0 for x in col_dict[c]]


fig, ax = plt.subplots(figsize=[16,10])
m = 0.
M = np.sum(idxDisplay)

# dummy plots for legend
legend_handle = list()
for c in col_dict:
    legend_handle.append(mlines.Line2D([], [], color=col_dict[c], marker='o',
                          markersize=15, label=c))

for row in df.loc[idxDisplay,:].iterrows():
    # row is a tuple: [index, actual_data], so we use row[1]
    plt.plot([row[1]['starttime'].to_pydatetime(), row[1]['endtime'].to_pydatetime()], [0+m/M,0+m/M],
```

```
    plt.plot([row[1]['starttime'].to_pydatetime(), row[1]['endtime'].to_pydatetime()], [0+m/M,0+m/M],
             'o-',color=col_dict[row[1]['source']],
             markersize=15, linewidth=2)
    m=m+1

ax.xaxis.set_minor_locator(dates.HourLocator(byhour=[0,12],interval=1))
ax.xaxis.set_minor_formatter(dates.DateFormatter('%H:%M'))
ax.xaxis.grid(True, which="minor")
ax.xaxis.set_major_locator(dates.DayLocator(interval=1))
ax.xaxis.set_major_formatter(dates.DateFormatter('\n%d\n%a'))

ax.set_ylim([-0.1,1.0])

plt.legend(handles=legend_handle,loc='best')
plt.show()
```

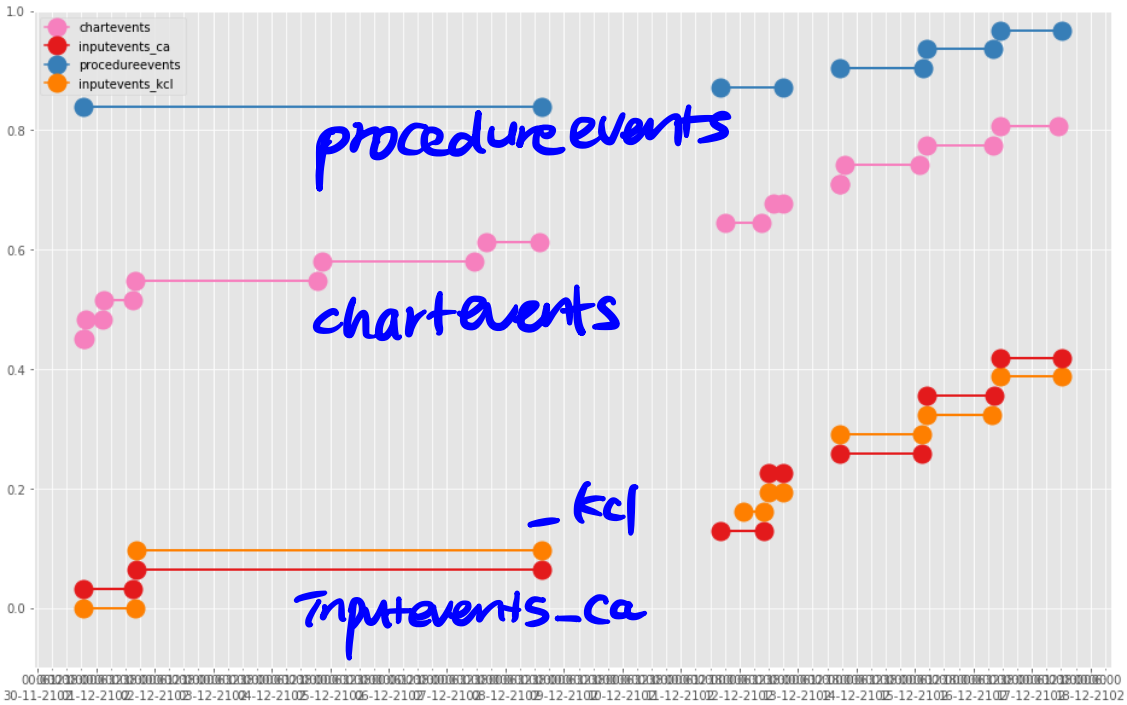
	num	starttime	endtime	source
0	1	Day 09, 18:10	Day 13, 15:44	inputevents_ca
136	1	Day 09, 18:00	Day 12, 15:15	chartevents
137	2	Day 12, 16:02	Day 12, 19:01	chartevents
138	3	Day 12, 21:00	Day 13, 14:03	chartevents
147	1	Day 09, 18:00	Day 13, 15:04	procedureevents

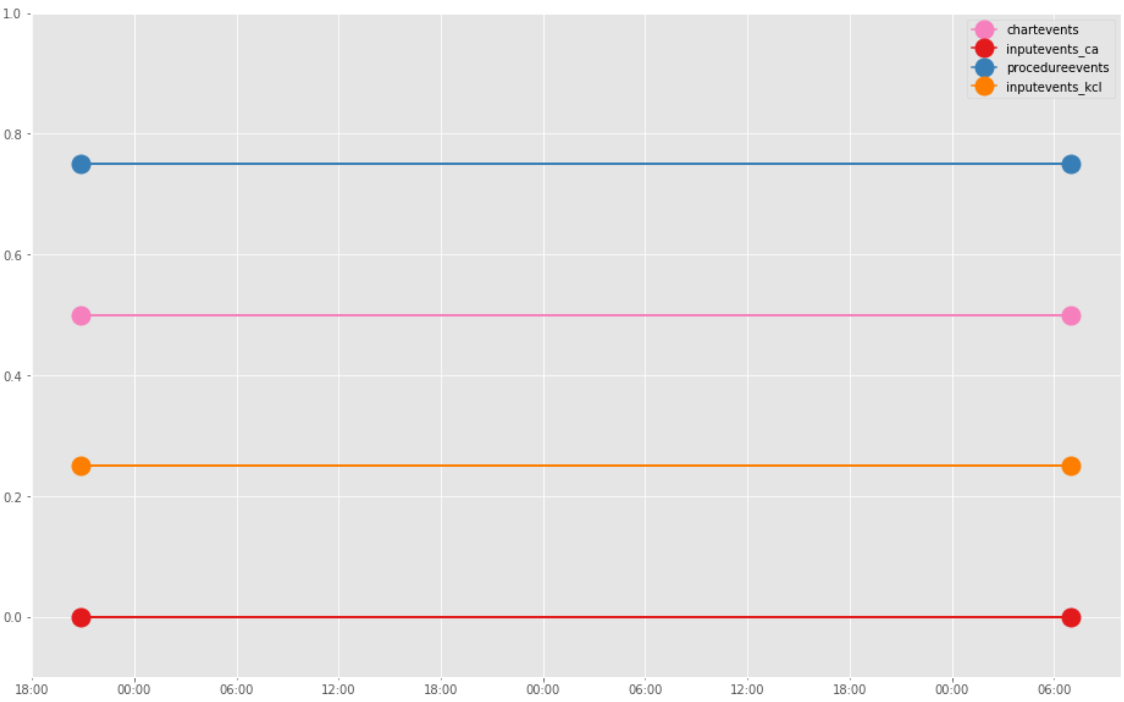


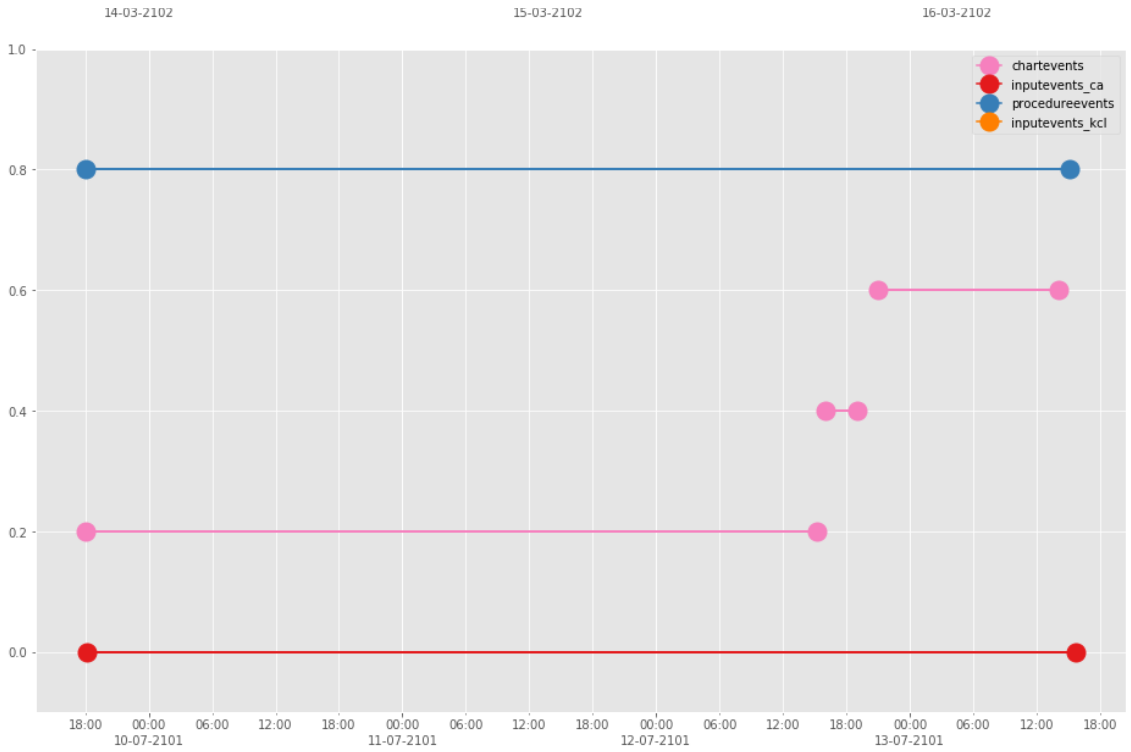
In [40]:

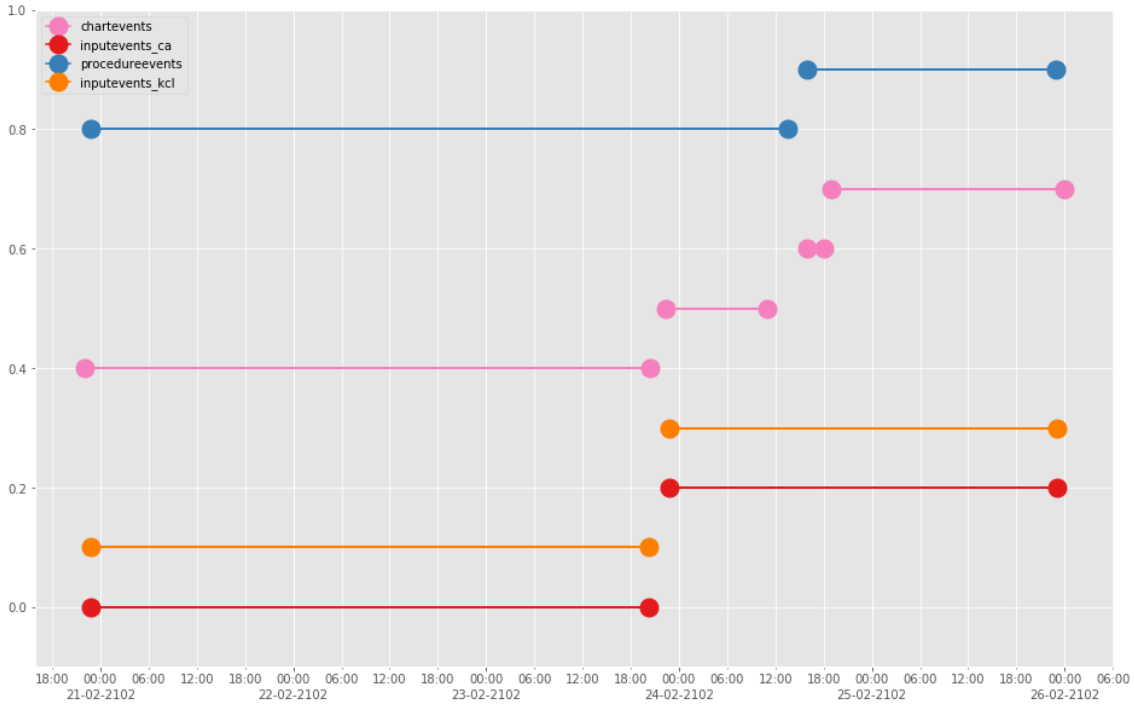
```
# print out the above for 10 examples

# compare the above durations
ce['source'] = 'chartevents'
ie['source'] = 'inputevents_kcl'
ie.loc[ie['label']=='Calcium','source'] = 'inputevents_ca'
pe['source'] = 'procedureevents'
df = pd.concat([ie[['icustay_id','num','starttime','endtime','source']], ce, pe])

for iid in np.sort(df.icustay_id.unique()[0:10]):
    iid = int(iid)
    # how many PROCEDUREEVENTS_MV dialysis events encapsulate CHARTEVENTS/INPUTEVENTS_MV?
    # vice-versa?
    idxDisplay = df['icustay_id'] == iid

    # no need to display here
    #display_df(df.loc[idxDisplay, :])

    # 2) how many have no overlap whatsoever?
    col_dict = {'chartevents': [247,129,191],
                'inputevents_kcl': [255,127,0],
                'inputevents_ca': [228,26,28],
                'procedureevents': [55,126,184]}

    for c in col_dict:
        col_dict[c] = [x/256.0 for x in col_dict[c]]


    fig, ax = plt.subplots(figsize=[16,10])
```

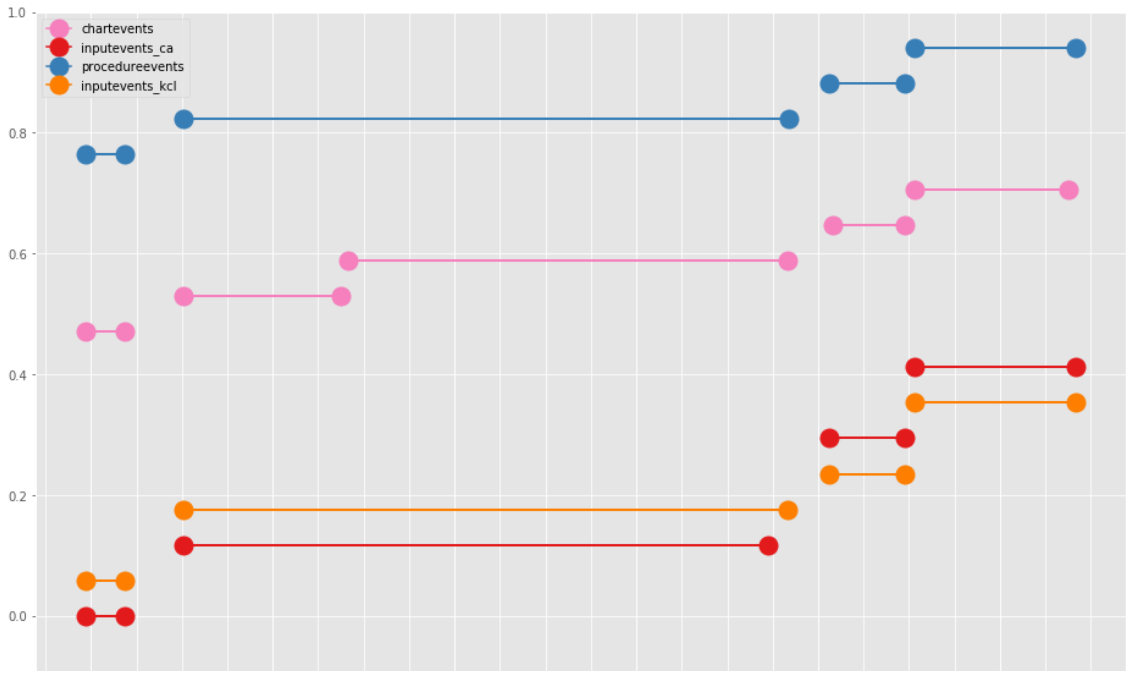
```
m = 0.
M = np.sum(idxDisplay)

# dummy plots for legend
legend_handle = list()
for c in col_dict:
    legend_handle.append(mlines.Line2D([], [], color=col_dict[c], marker='o',
                          markersize=15, label=c))

for row in df.loc[idxDisplay,:].iterrows():
    # row is a tuple: [index, actual_data], so we use row[1]
    plt.plot([row[1]['starttime'].to_pydatetime(), row[1]['endtime'].to_pydatetime()], [0+m/M,0+m/M],
            'o-',color=col_dict[row[1]['source']],
            markersize=15, linewidth=2)
    m=m+1

ax.xaxis.set_minor_locator(dates.HourLocator(byhour=[0,6,12,18],interval=1))
ax.xaxis.set_minor_formatter(dates.DateFormatter('%H:%M'))
ax.xaxis.grid(True, which="minor")
ax.xaxis.set_major_locator(dates.DayLocator(interval=1))
ax.xaxis.set_major_formatter(dates.DateFormatter('\n%d-%m-%Y'))

ax.set_ylim([-0.1,1.0])

plt.legend(handles=legend_handle,loc='best')

# if you want to save the figures, uncomment the line below
#plt.savefig('crrt_' + str(iid) + '.png')
```

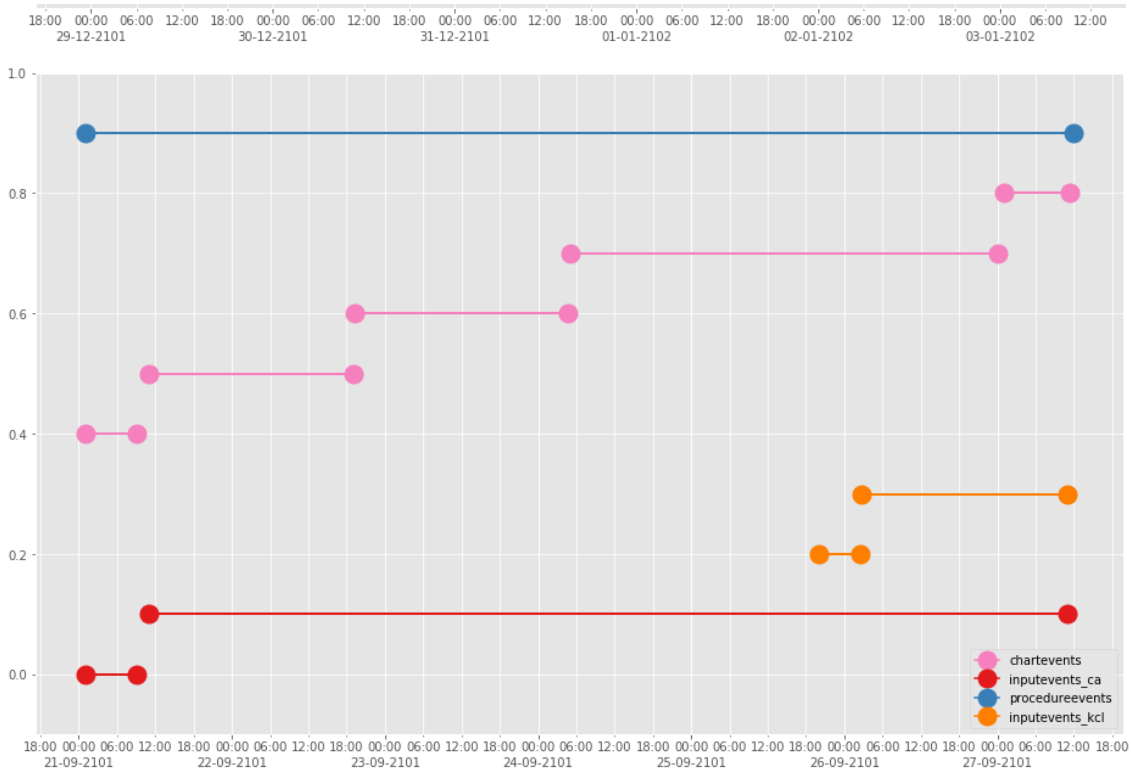


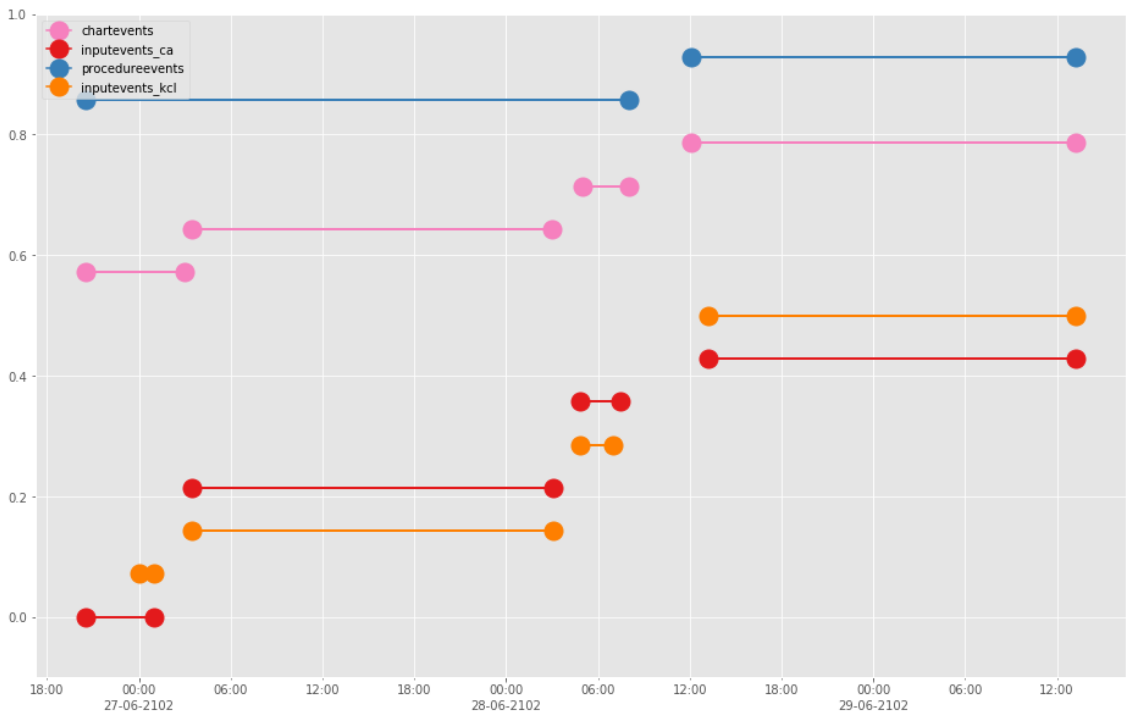


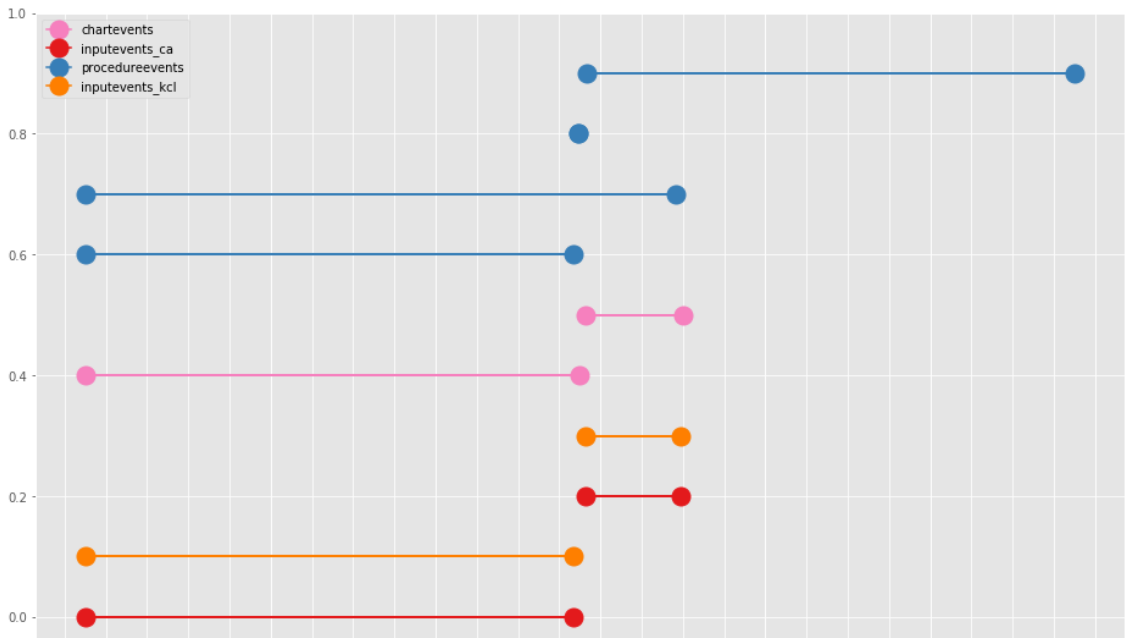

14-03-2102
15-03-2102
16-03-2102
chartevents
inputevents_ca
procedureevents
inputevents_kcl
1.0
0.8
0.6
0.4
0.2
0.0
18:00
00:00
10-07-2101
06:00
12:00
18:00
00:00
11-07-2101
06:00
12:00
18:00
00:00
12-07-2101
06:00
12:00
18:00
00:00
13-07-2101
06:00
12:00
18:00

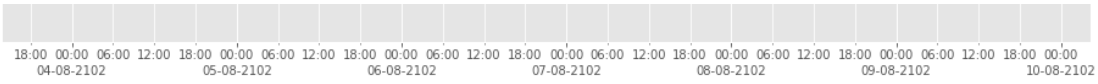

chartevents
inputevents_ca
procedureevents
inputevents_kcl
1.0
0.8
0.6
0.4
0.2
0.0
18:00
00:00
21-02-2102
06:00
12:00
18:00
00:00
22-02-2102
06:00
12:00
18:00
00:00
23-02-2102
06:00
12:00
18:00
00:00
24-02-2102
06:00
12:00
18:00
00:00
25-02-2102
06:00
12:00
18:00
00:00
26-02-2102
06:00

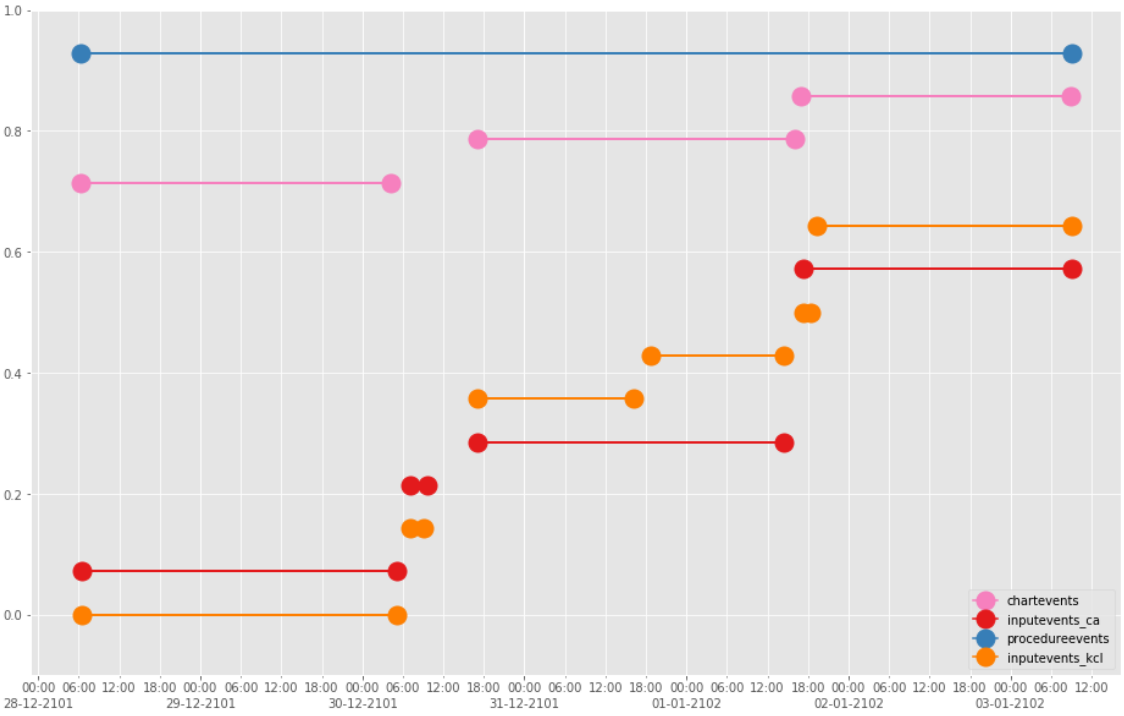

chartevents
inputevents_ca
procedureevents
inputevents_kcl
1.0
0.8
0.6
0.4
0.2
0.0

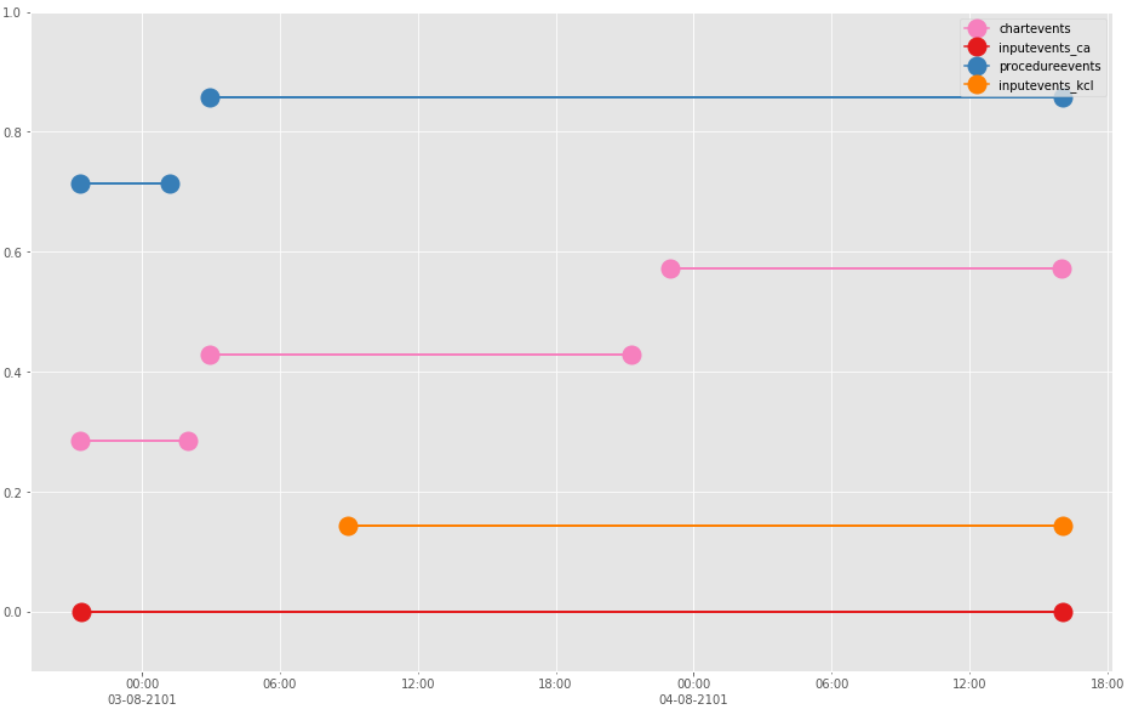

18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00
29-12-2101
30-12-2101
31-12-2101
01-01-2102
02-01-2102
03-01-2102
1.0
0.8
0.6
0.4
0.2
0.0
chartevents
inputevents_ca
procedureevents
inputevents_kcl
18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00
21-09-2101
22-09-2101
23-09-2101
24-09-2101
25-09-2101
26-09-2101
27-09-2101


1.0
0.8
0.6
0.4
0.2
0.0
chartevents
inputevents_ca
procedureevents
inputevents_kcl
18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00
27-06-2102
28-06-2102
29-06-2102


1.0
0.8
0.6
0.4
0.2
0.0
chartevents
inputevents_ca
procedureevents
inputevents_kcl


18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00
04-08-2102
05-08-2102
06-08-2102
07-08-2102
08-08-2102
09-08-2102
10-08-2102


1.0
0.8
0.6
0.4
0.2
0.0
chartevents
inputevents_ca
procedureevents
inputevents_kcl
00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00 18:00 00:00 06:00 12:00
28-12-2101
29-12-2101
30-12-2101
31-12-2101
01-01-2102
02-01-2102
03-01-2102


1.0
0.8
0.6
0.4
0.2
0.0
chartevents
inputevents_ca
procedureevents
inputevents_kcl
00:00
03-08-2101
06:00
12:00
18:00
00:00
04-08-2101
06:00
12:00
18:00