~~*MANAGING*~~ **TRANSFORMING** HEALTHCARE PROCESSES in a **COMPLEX** ~~*BIG*~~ DATA WORLD

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Who Am I?

- Vice-Dean, Graduate Programs, Faculty of Engineering, uOttawa
- Principal Investigator, Intelligent Data Warehouse Laboratory
- www.create-best.com – Biomedical Smartphone Apps
- **Previously**
  - Enterprise BI and BPM - Ottawa, McGill, William Kaiser Hospital (Toronto)
  - Startup: ESRI Canada (Ottawa Research Center)
  - Startup: ProntoForms (Wesley Clover company)
  - Undergrad Software Engineering, 100% COOP
  - PhD Electronic Business (Engineering, Telfer, Arts)
- **Ancient History**
  - Industry Consultant / Trainer: Technology Transformation Projects 1991-2003
  - Scandinavia: Krysten Nygaard, Software Engineering
  - Silicon Valley: Terry Winograd: Google, Ed Feigenbaum: Expert Systems

Architecture and Security in Community Health

The role of **SECURITY**

in **mission critical processes** is to ….

ENABLE quicker, easier, and more effective access to **DATA**

for those actors and systems which **depend on it**

The Communication Revolution

- **We are at the beginning of a third communication revolution that is transforming our world!**
  - Electronic Digital Communication (**~1960s**, Internet, Satellites, Cellular)
  - Written Communication (**~3600 BC**, http://www.ancient.eu/timeline/writing/)
  - Oral Communication (**maybe a million years ago?** http://www.historyworld.net/wrldhis/PlainTextHistories.asp?historyid=ab13)

- **We are transitioning from the Industrial Age to the Information Age**
- **Industrial Age** (Automate)
  - mass production: standardization, **repeatable processes**
- **Information Age** ("Informate" – Big Data)
  - mass customization: constant feedback, **constant change**

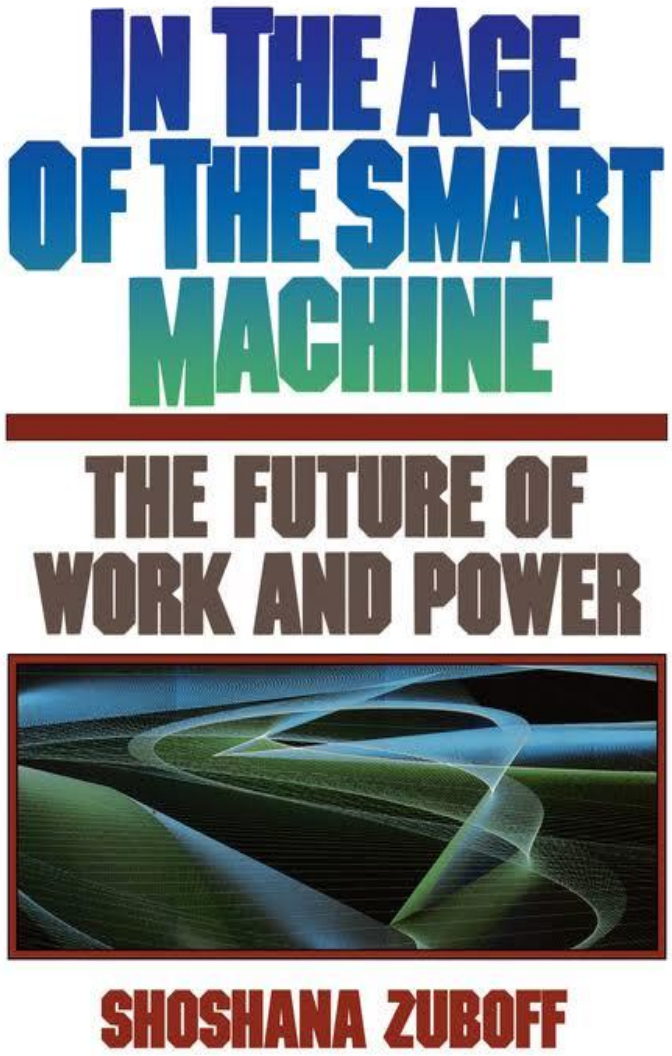
Our Big Data World

- Shoshan Zuboff,
  - **the duality of information technology as an informating and an automating technology**
  - In the Age of the Smart Machine : The Future of Work and Power (1988) https://en.wikipedia.org/wiki/Shoshana_Zuboff
  - Three Laws:

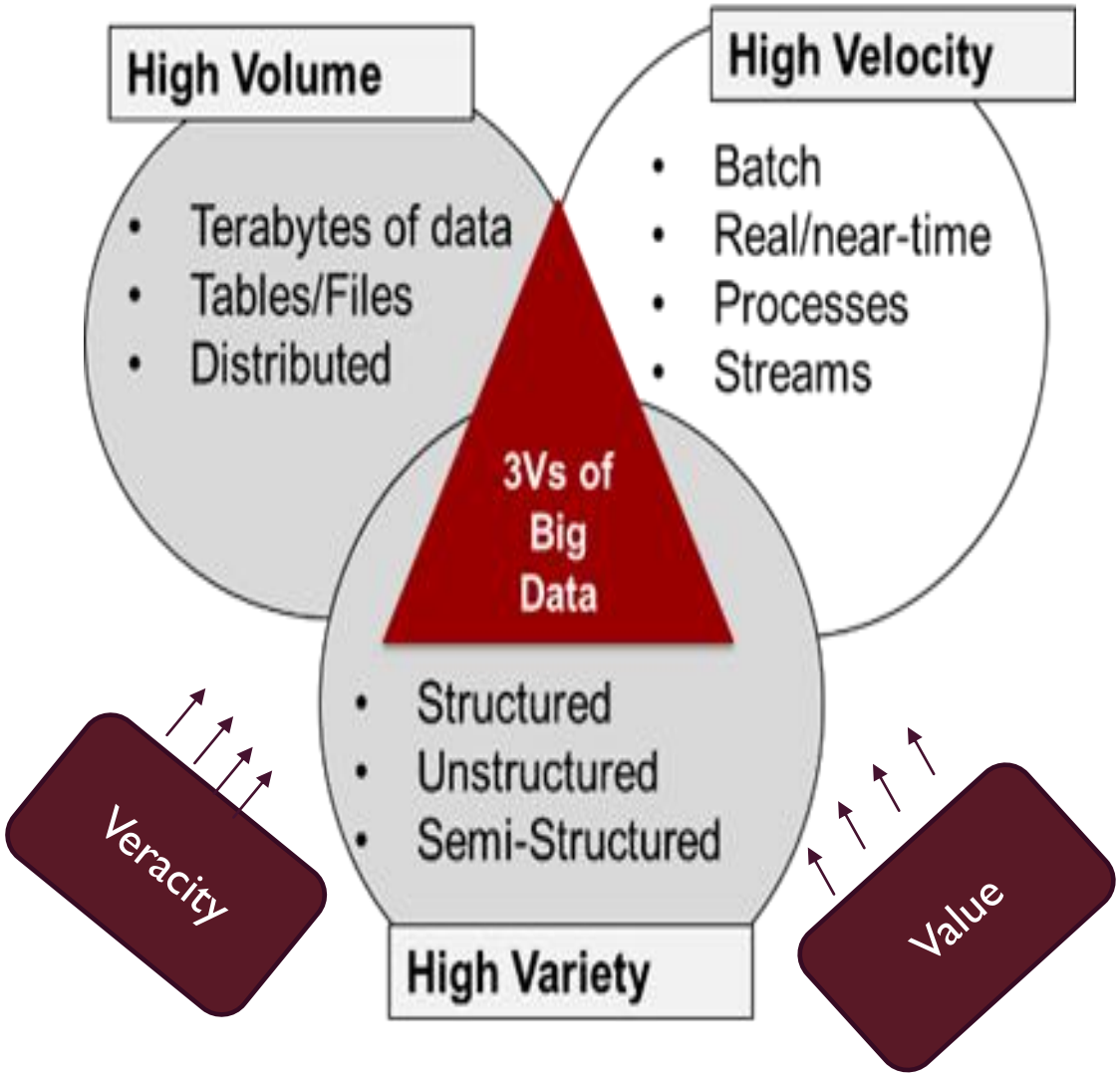
Everything that can be automated will be ***automated.***

Everything that can be informated will be ***informated.***

Every digital application that can be used for surveillance and control will be used for ***surveillance and control.***

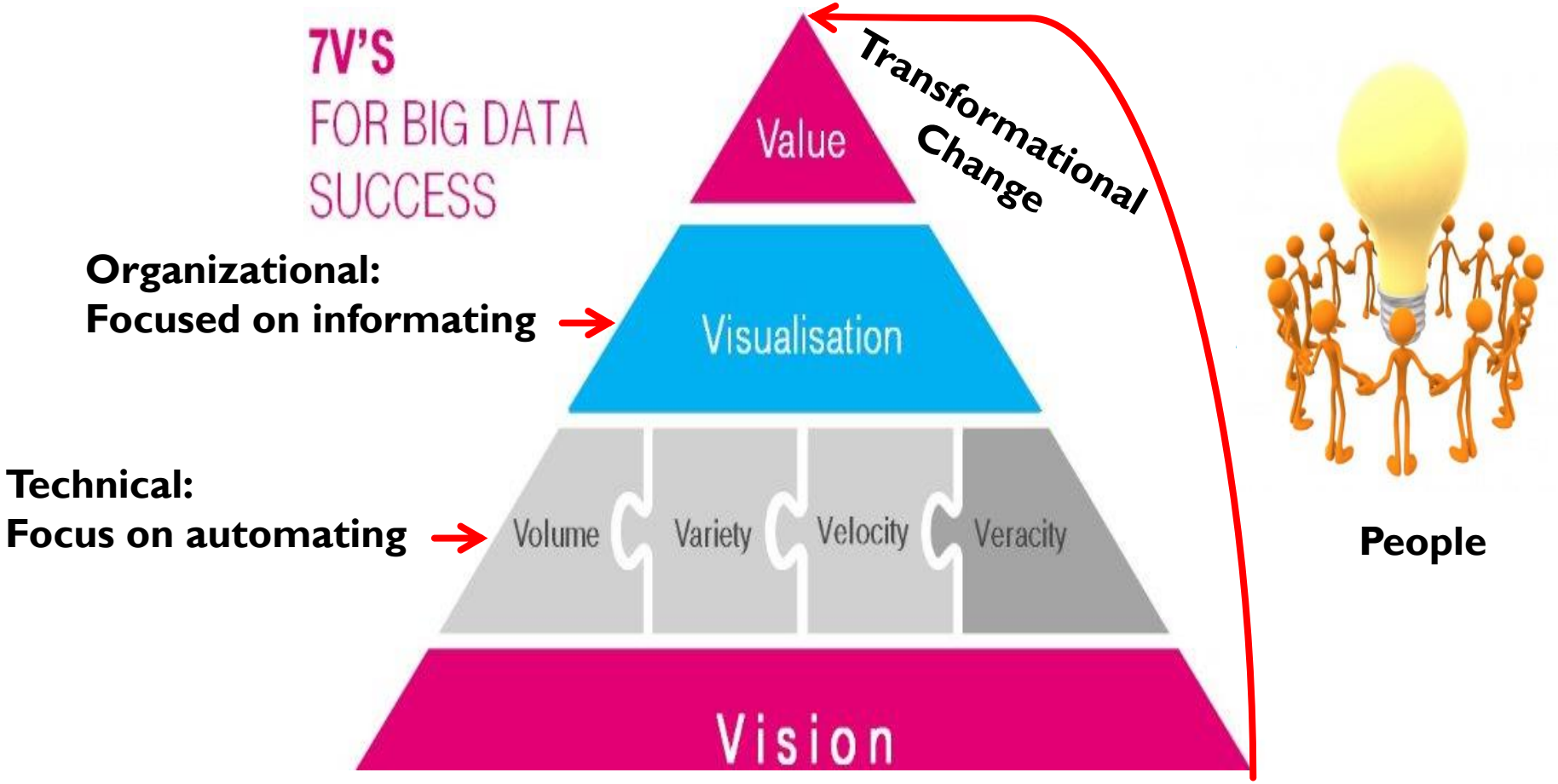


Big Data – Original Technical Definition … Evolving



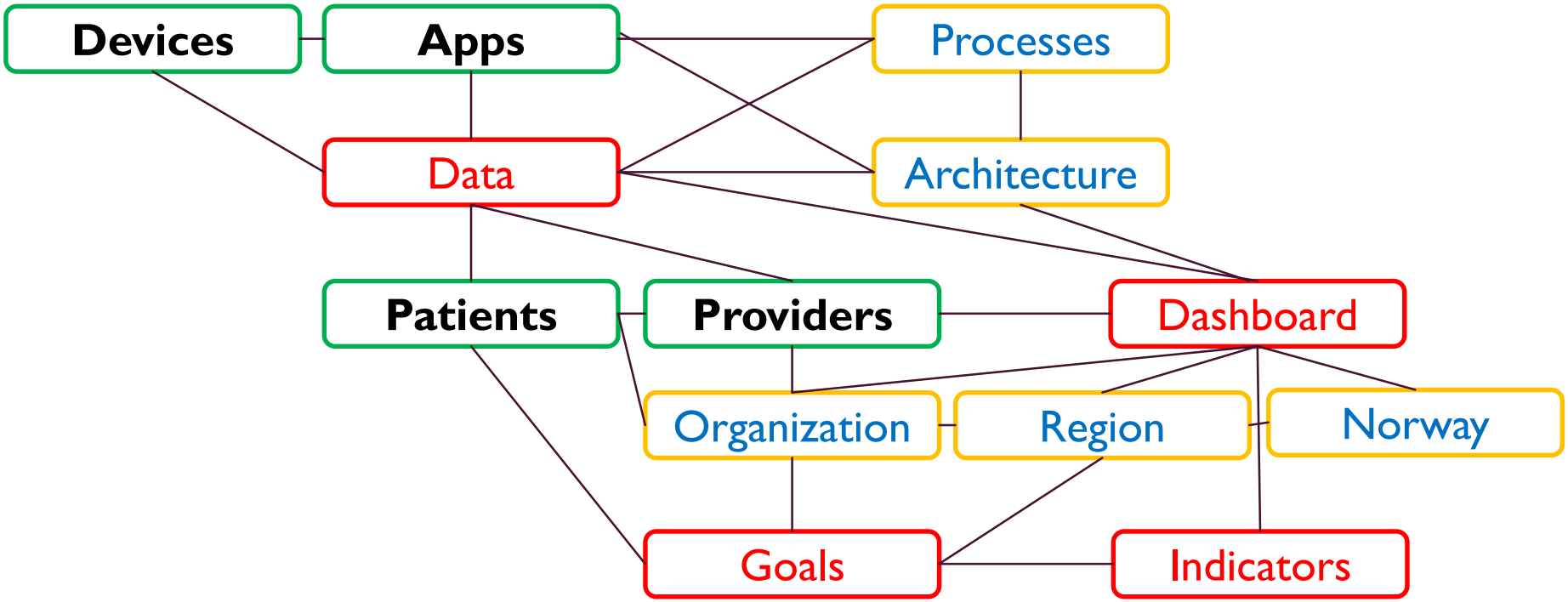
Variabi ity !!!

My Current Favorite Definition of Complex ~~Big~~ Data



- See article by Vit Soupal at https://www.linkedin.com/pulse/7vs-successful-big-data-project-vit-soupal
- ** **Variability (constant change) replaced by Vision (transformational change)!** ☺

Transforming Care Processes in a Complex Data World
(Intromat Project – Bergen, Norway)



Online Community – Knowledge Transfer - Innovation

Policy Regulation – Advocate – Accommodate - Change

Some Projects

- Cloud Hosted Performance Management for Community Care
  - Architecture, Indicators, Dashboard
- Toronto: Cardiac Care Performance Monitoring Dashboard
  - Process, Architecture, Goals, Indicators, Dashboard
- Application Meta-Model of Care Process Monitoring
  - Data Architecture (sort of)
- Norway Intromat Project: Schizofreni Process Mining
  - Reverse Engineering a data model of care process

Cloud Hosted Performance Management for Community Care – Champlain LHIN (Ottawa)

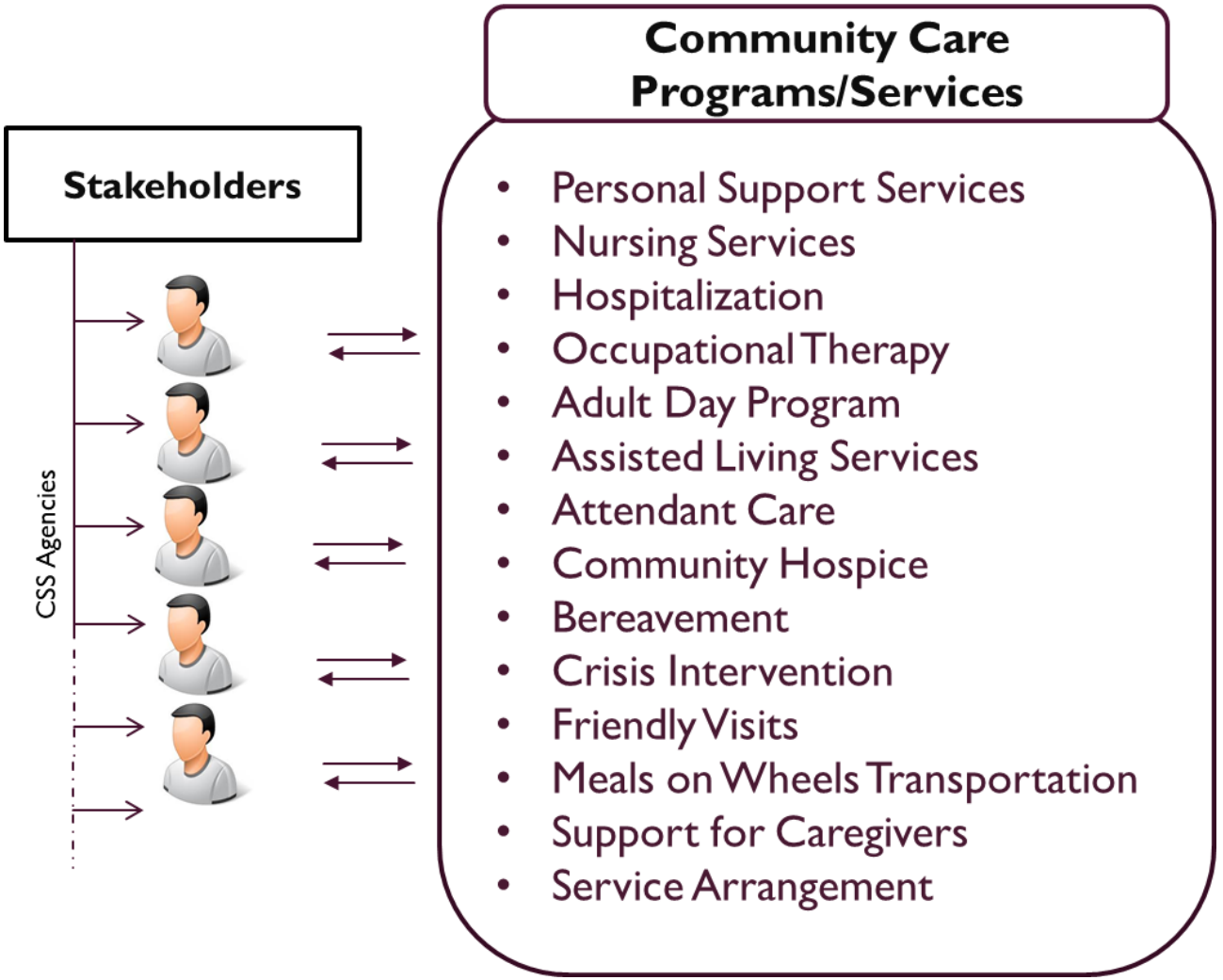
A Cloud-based Surveillance and Performance Management Architecture for Community Healthcare

Benjamin Eze, PhD Thesis, 2019

Community Care Performance Management
Integrating CHCD & 54 Service Agencies

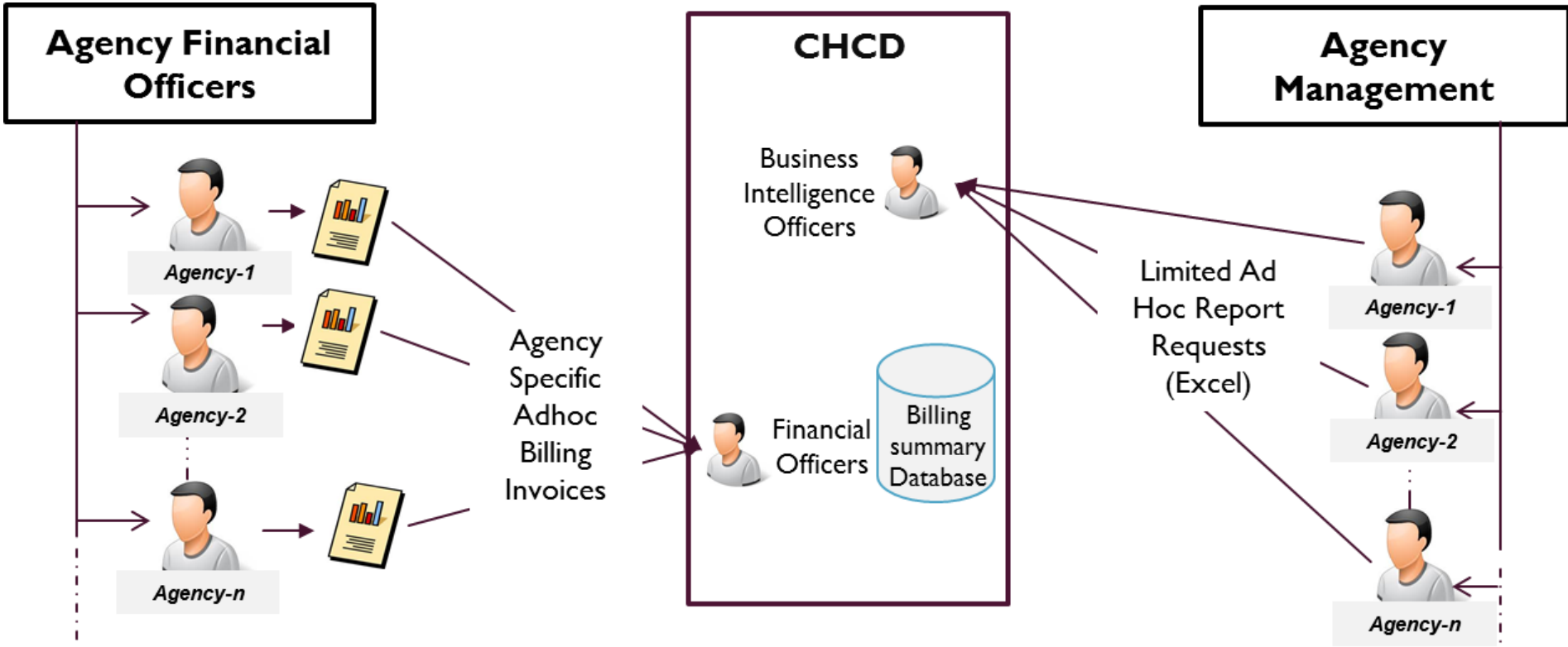
- Champlain region has a population of about 1.2 million.
- Champlain LHIN takes care of about 60,000 patients annually.
- Patients receive over 2 dozen community healthcare services through the LHIN and 54 Community Support Services (CSS) Agencies.
- CSS Agencies are small community healthcare organizations with an active patient population ranging from a few hundred up to 10,000, with limited budgets and small self-managed ad-hoc IT systems.
- Each agency has its own data silo
- Results in service duplication, limited coordination of care delivery

Community Care Services



Current State of Performance Management

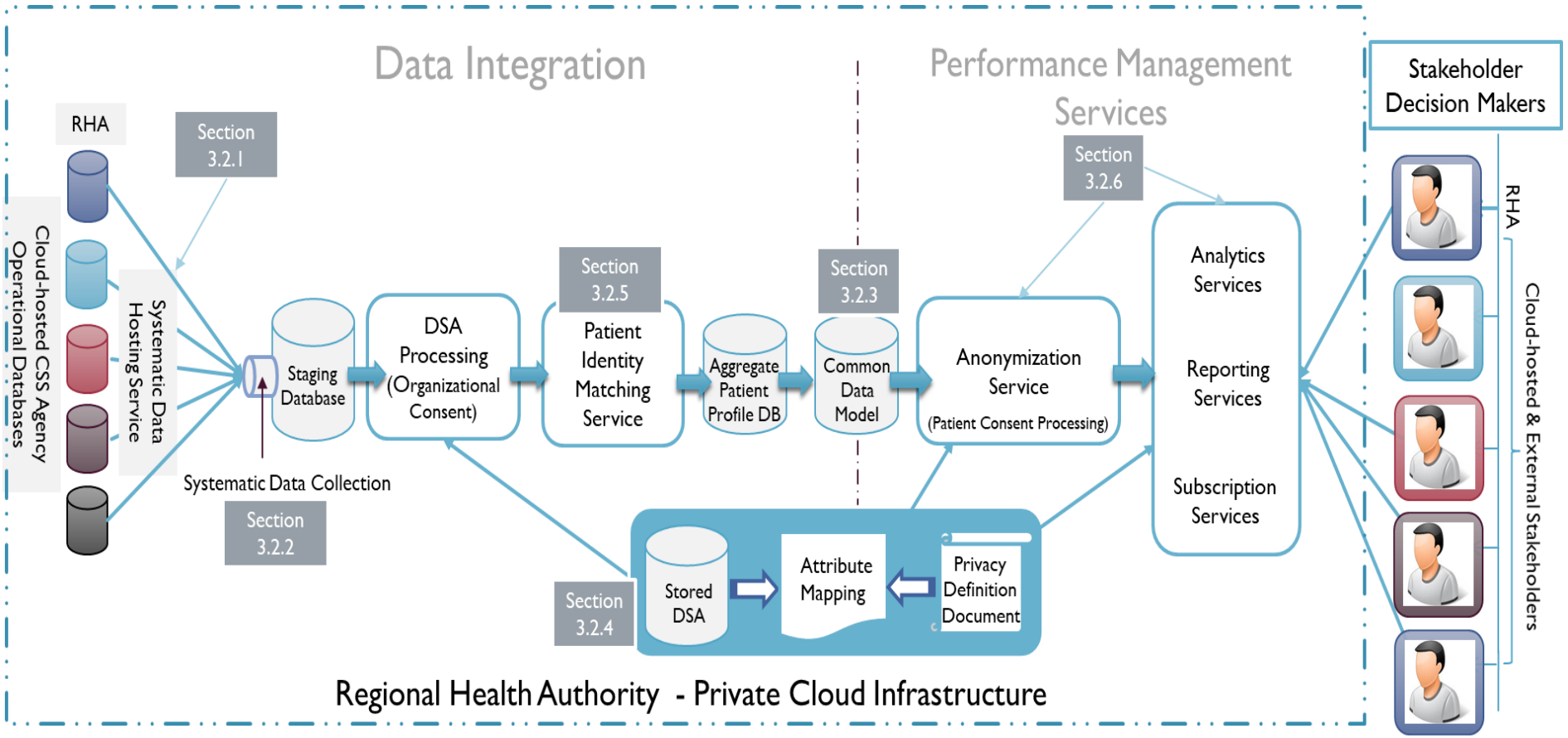
Ad Hoc, Incomplete, Manually-Intensive Reports



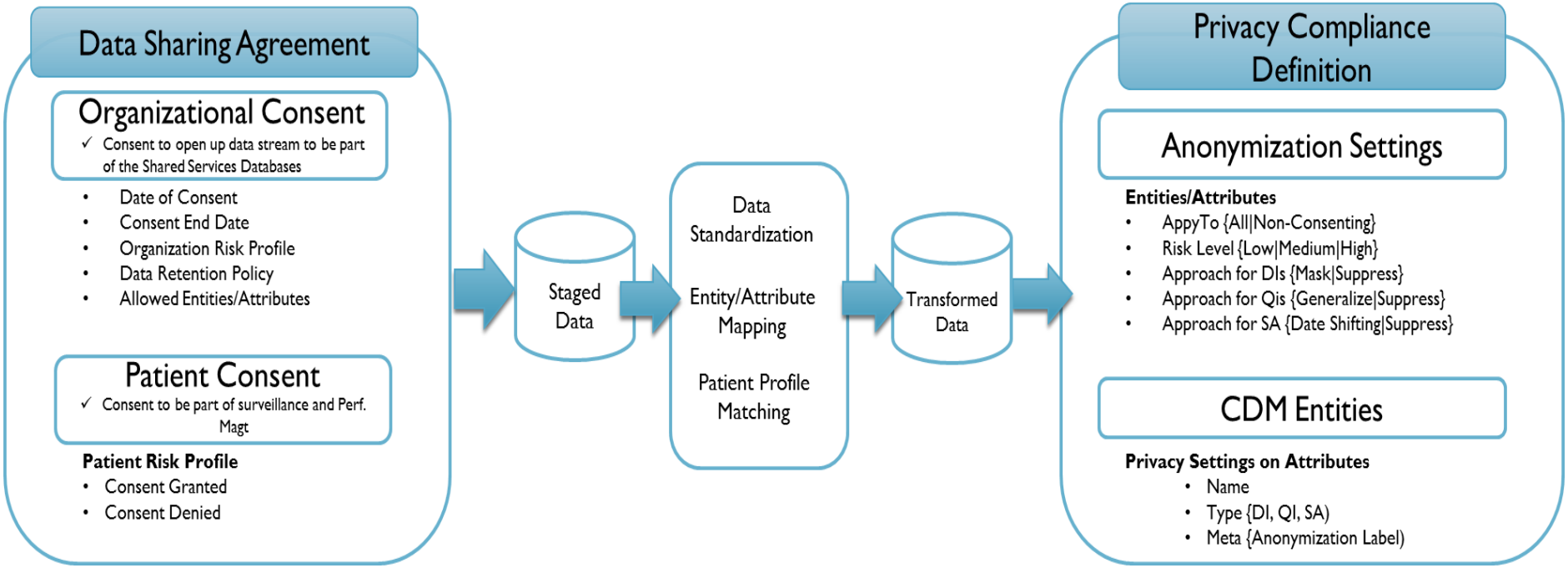
Options Evaluated

- **Option 1**
  - Have each agency implement a data push protocol standard like HL7 CDA or openEHR.
- **Option 2**
  - Implement the same Community Care Information System (CCIS) for all agencies using a Software-as-a-Service (SaaS) application.
- **Option 3***
  - Cloud-based Systematic Hosting Service that supports both organizational autonomy by providing data separation but with zero maintenance or support skills by agency staffs.

Cloud-based Architecture for Performance Management of Community Care



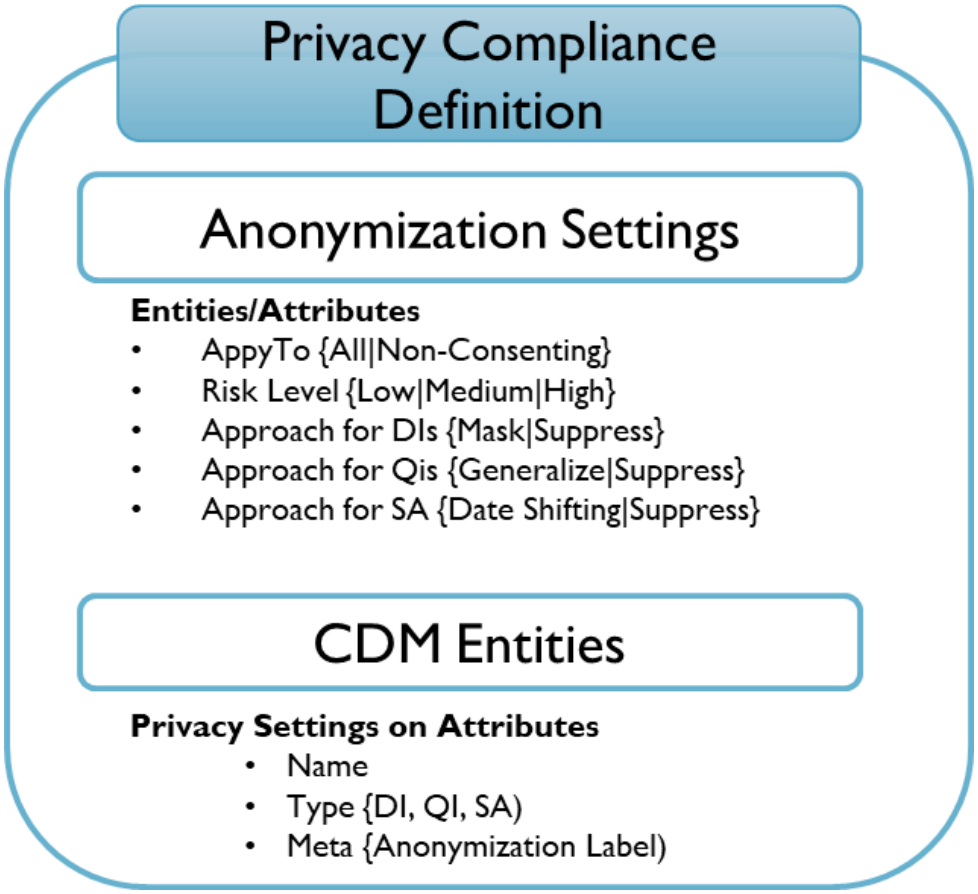
Privacy Compliance Model



- Organization consent has local significance for each incoming data stream.
- Patient consent can be global, local (specific to organization), or partial (apply to select data entities and attributes).
- DI = Deterministic Identifier, QI = Quasi-identifier, SA = Sensitive Attribute

Privacy Compliance Definition Document

- Privacy Compliance Definition Document is the anonymization configuration for Performance Management Services.
- Anonymization is applied to data based on the report recipient
- Ensures external stakeholders receive only anonymized data while participating stakeholders received data sets with partial anonymization (based on patient consent)



Preliminary Results

- 48 of 54 CSS with 150k patients are cloud-hosted.
- 17 agencies, with over 30k patients, have signed the DSA
- Nightly data collection and aggregation across the operational databases.
- Follows an all-or-nothing approach to patient consent
- Nightly patient identity matching and progressing clustering of patient profiles
- 25k patients have matches
- 3k patients have possible matches
- 8 active report subscriptions for LHIN and CSS managers

Cardiac Care Performance Monitoring Dashboard
William Osler Hospital, Toronto

Enterprise Architecture for
Model-Driven Clinical Operations Management
in Value-Based Hospitals

Alain Mouttham, PhD Thesis, 2016

Transformation From "Fee for Service" to Value-Based Hospitals

Fee for Service

Vertical

Provider-focused

"Silos"

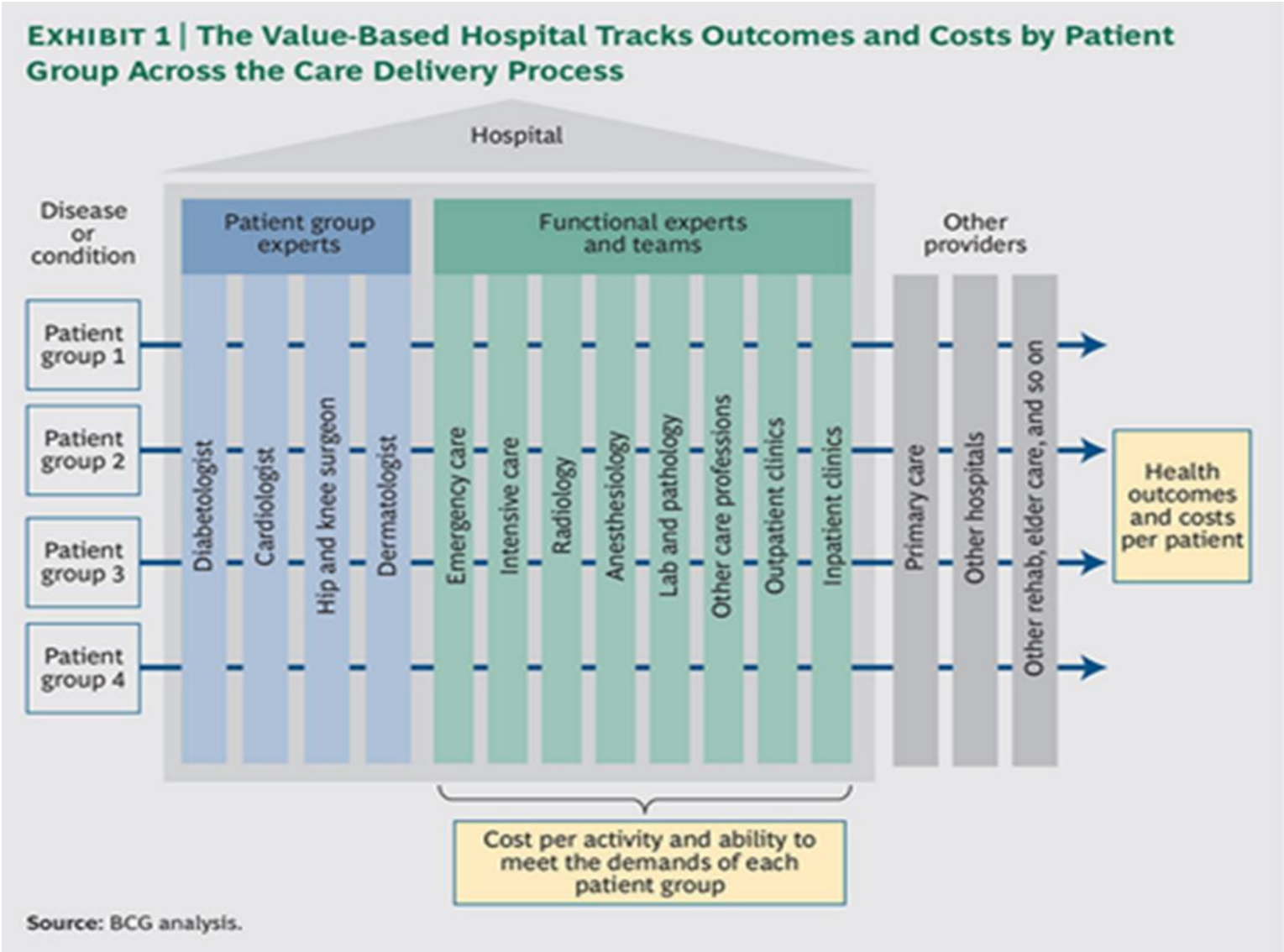
vs

Quality of Care SLA

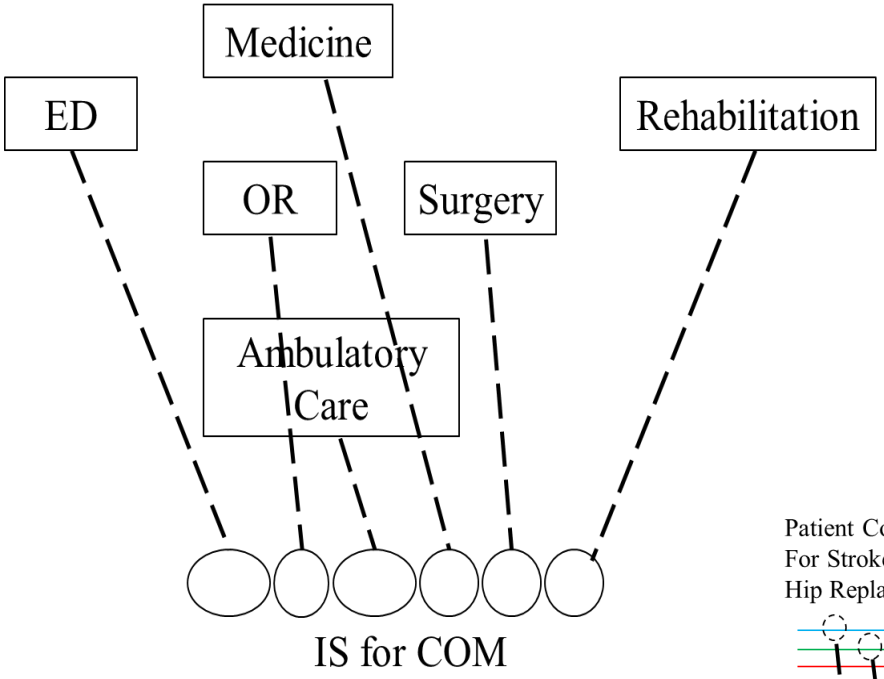
Horizontal

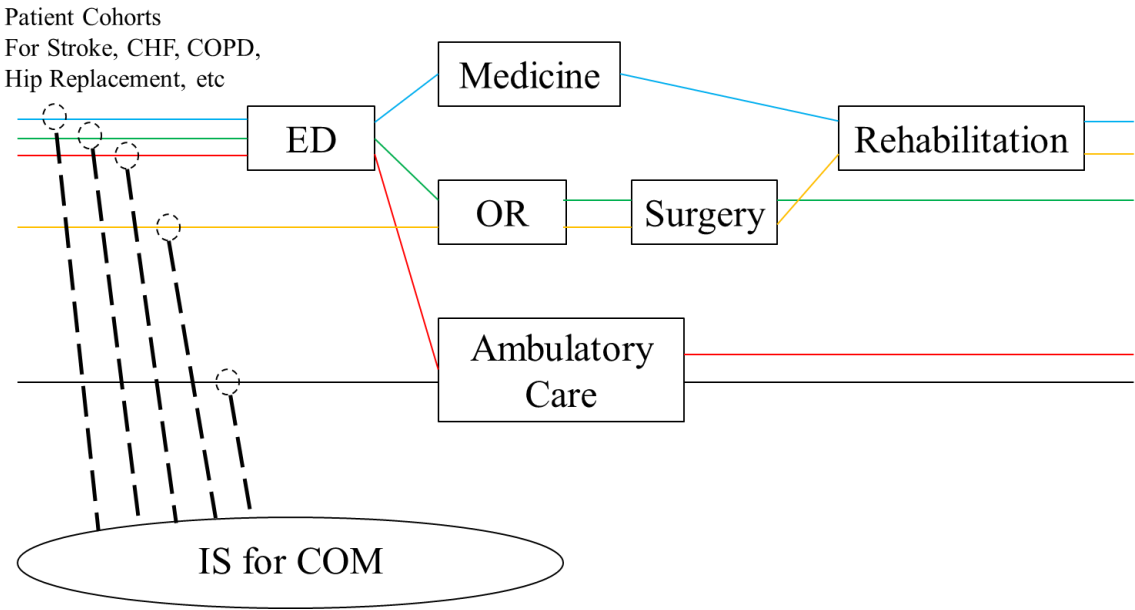
Patient-focused

Service Lines



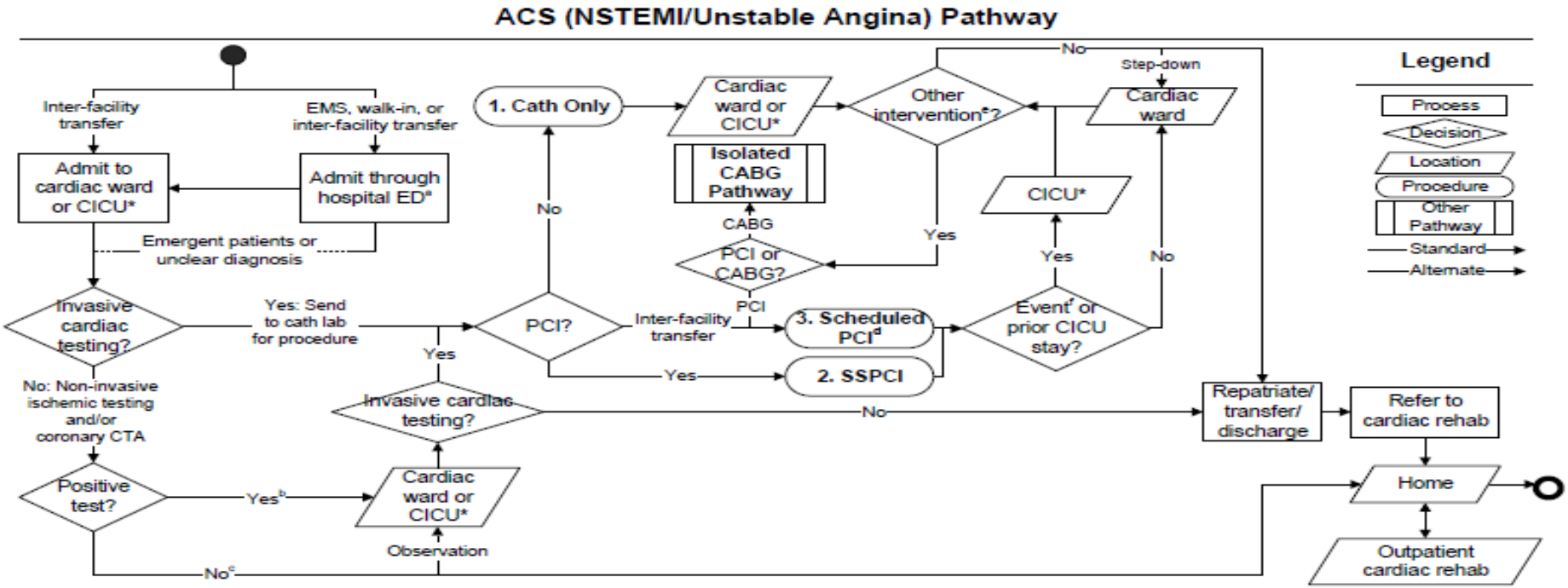
Information Systems for Clinical Operations Management
Silos vs Service Lines





Quality Based Procedure (Ministry of Health, Ontario, Canada) Acute Coronary Syndrome

Figure 6: Pathway for NSTEMI/UA



1. **Cath Only** – with or without FFR/IVUS/OCT
2. **Same Sitting PCI (SSPCI)** – with or without FFR/IVUS/OCT
3. **Scheduled PCI** (includes staged PCI) – with or without FFR/IVUS/OCT

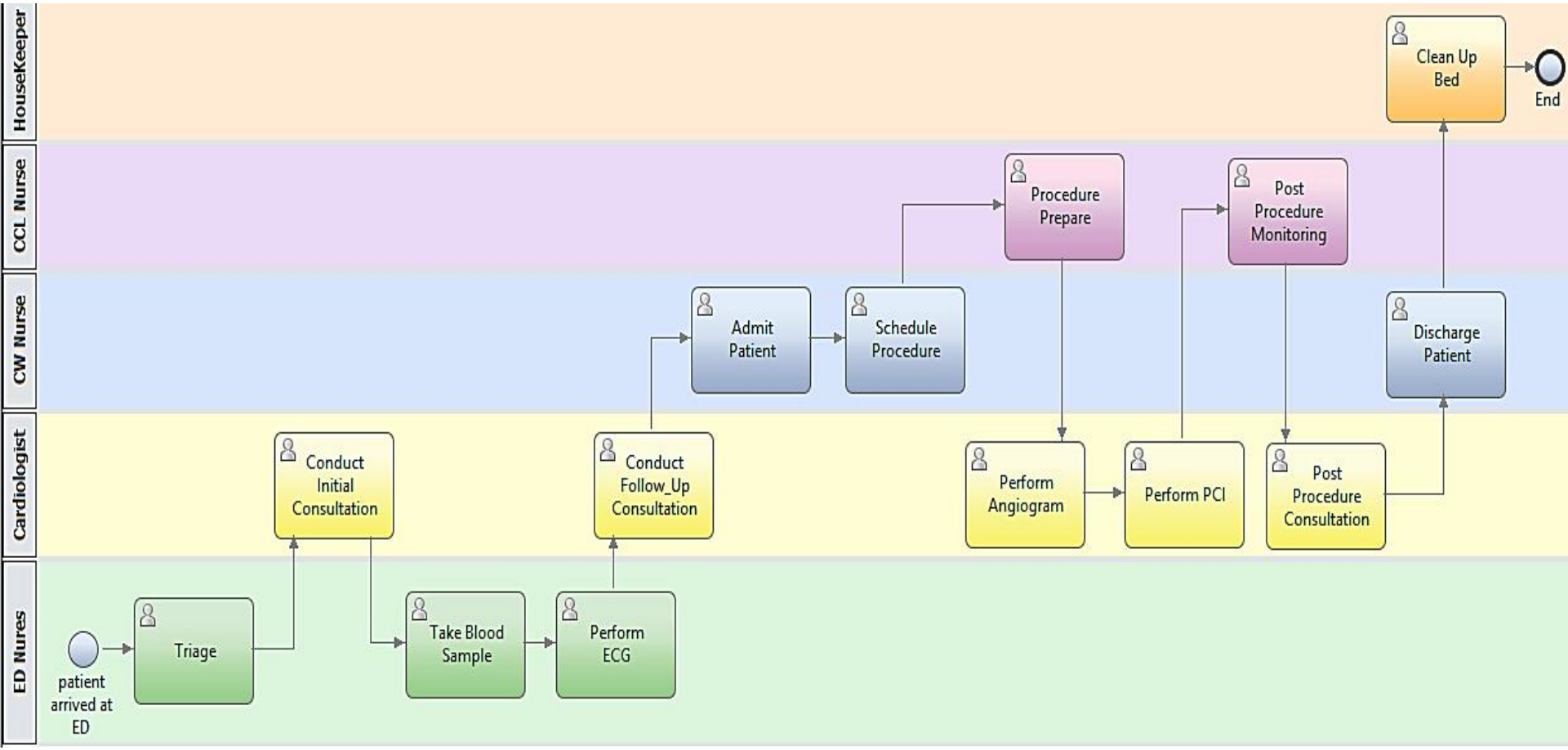
a. Patient may be admitted directly to CICU or ward depending on hemodynamic status. A patient who requires immediate further testing is emergent, has unclear diagnosis, or has undetermined severity of disease.
b. Patient receives non-invasive ischemic testing, medical management, or coronary CTA and cath with or without PCI.
c. Patient receives non-invasive ischemic testing or coronary CTA Only.
d. Scheduled PCI are NSTEMI/UA inpatients or transferred from other hospital. Outpatients are reclassified.***
e. Patient may require CABG after cath or PCI; delayed PCI or medical management after cath.
f. An event is any cath/PCI with heart failure, cardiac arrest, cardiac tamponade, transfusion for bleeding, etc.; with or without IABP*, ventilator, inotropes, temp pacer, mechanical circulatory support, dialysis, etc.

***__IMPORTANT__: The NSTEMI/UA patients who are discharged home with arrangements for an outpatient scheduled/staged PCI should be reclassified as **stable angina** patients.

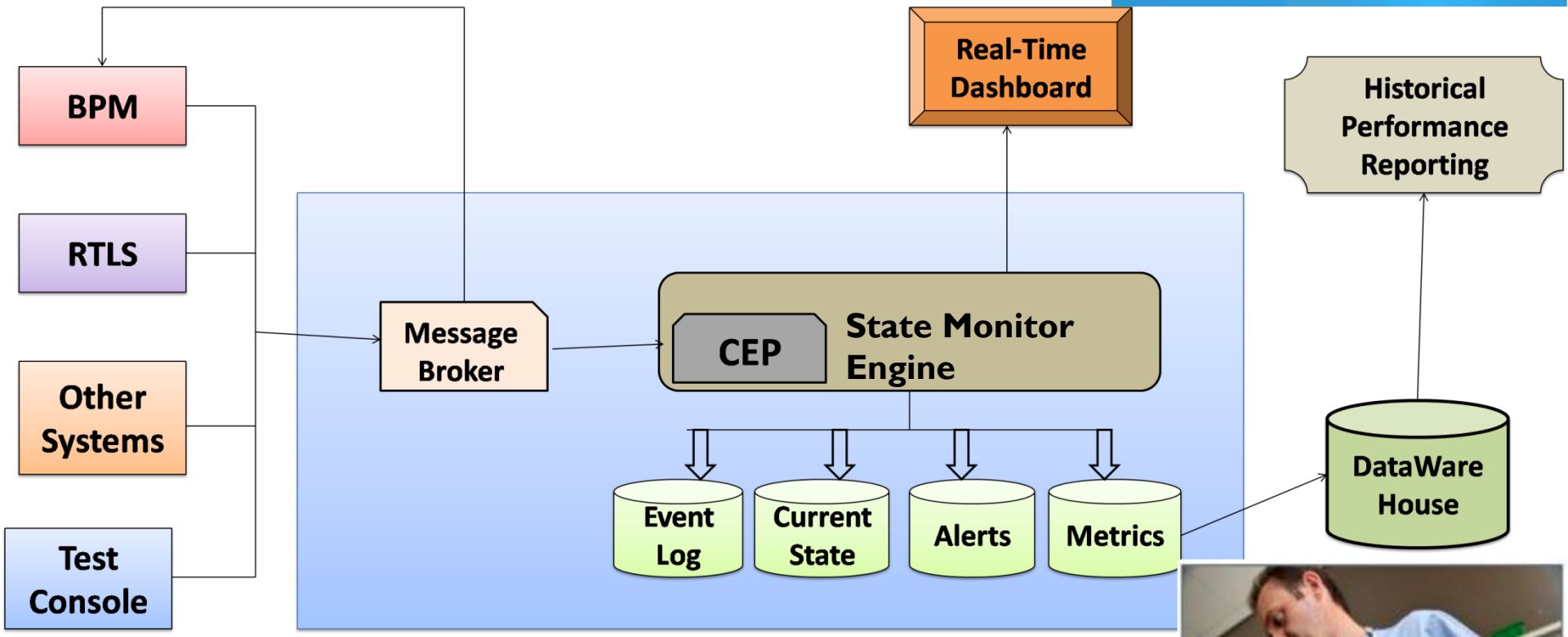
* CICU = Cardiac Intensive Care Unit; IABP = Intra-Aortic Balloon Pump

Cardiac Care Process
Business Process Model Notation (BPMN) – IBM BPM

GOAL: Ensure PCI Operation Performed within 90 minutes of heart attack

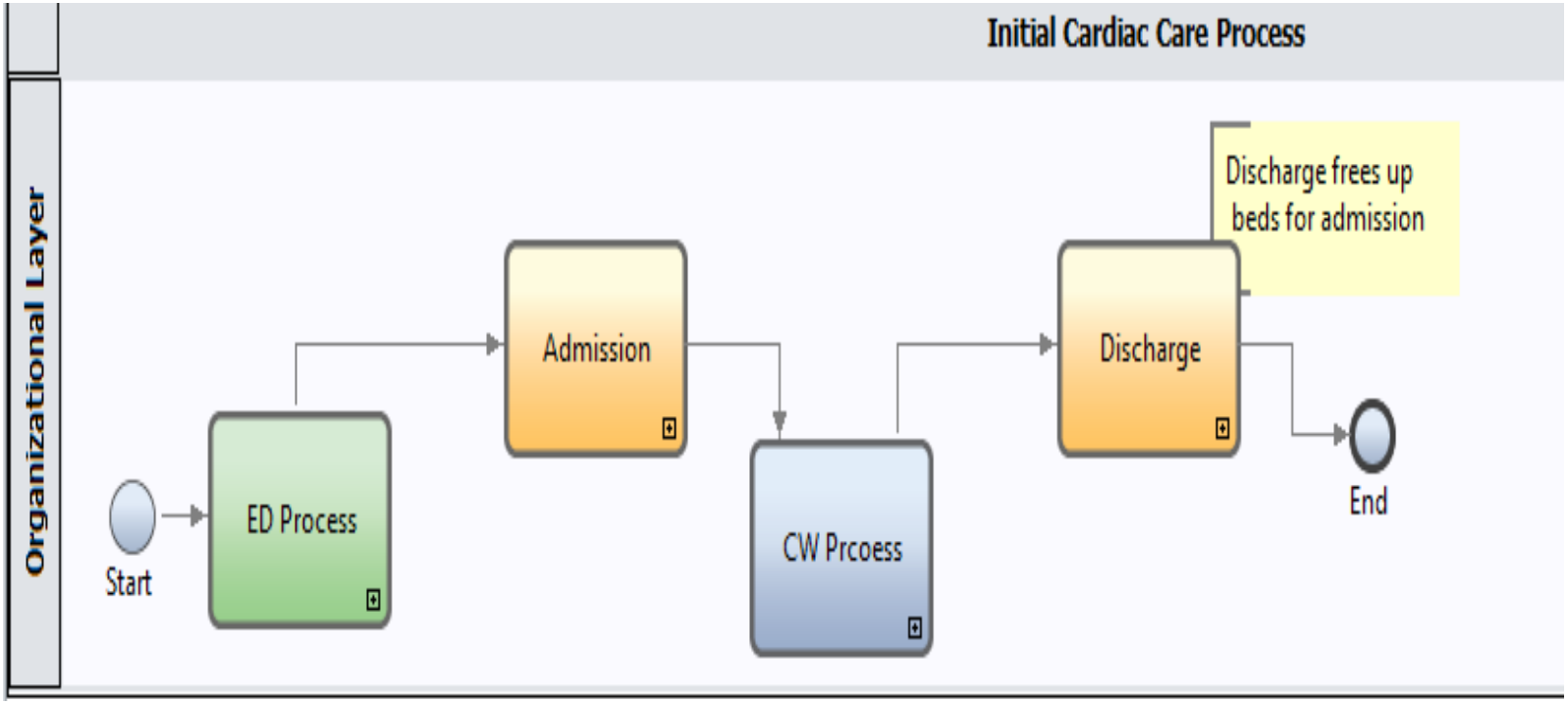


BPM, RTLSS, Dashboarding



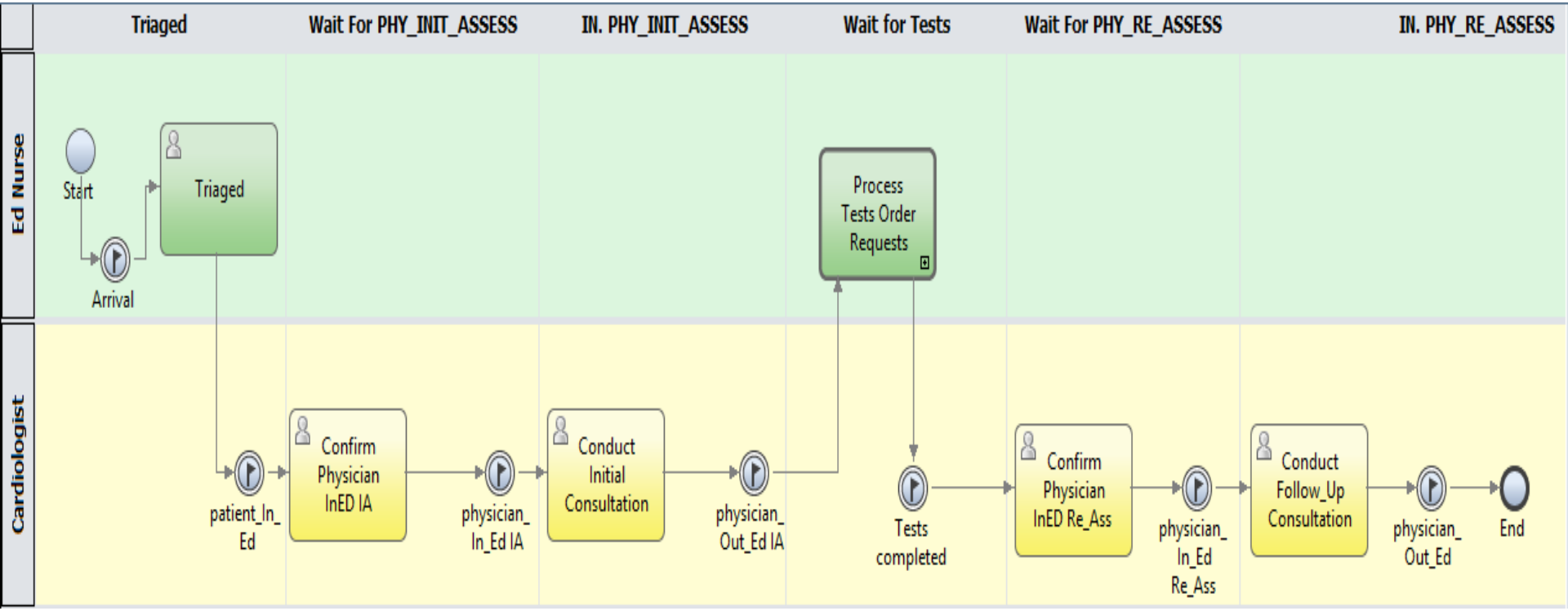
Model into 3 Layers: Organizational, Processes, Systems
Organizational Layer

- Bottlenecks, quality issues happen at handoffs across organizational boundaries



Integrate Monitoring into Processes Layer

- Horizontal "Swim lanes" for different roles
- Vertical swim lanes to identify states



Monitoring Patient Progress (with targets)

Patient States

Search:

State	Start Time	End Time	Duration (mins)	Target (mins)
IN_BED_CW	2013-03-02 11:13:00.0	N/A	50	N/A
IN_TRANSPORT_CW	2013-03-02 11:02:00.0	2013-03-02 11:13:00.0	11	15
WAIT_FOR_TRANSPORT_CW	2013-03-02 10:39:00.0	2013-03-02 11:02:00.0	23	15
WAIT_FOR_BED_CW	2013-03-02 10:13:10.0	2013-03-02 10:39:00.0	26	480
IN_BED_ED	2013-03-02 10:12:00.0	2013-03-02 10:13:10.0	2	N/A
IN_PHYS_RE_ASSESS	2013-03-02 10:00:00.0	2013-03-02 10:12:00.0	12	N/A
WAIT_FOR_PHYS_RE_ASSESS	2013-03-02 09:40:00.0	2013-03-02 10:00:00.0	20	30
WAIT_FOR_ORDERS_EXECUTION	2013-03-02 08:19:00.0	2013-03-02 09:40:00.0	81	30
IN_BED_ED	2013-03-02 08:15:00.0	2013-03-02 08:19:00.0	4	N/A
IN_PHYS_INIT_ASSESS	2013-03-02 08:12:00.0	2013-03-02 08:15:00.0	3	N/A
WAIT_FOR_PHYS_INIT_ASSESS	2013-03-02 08:10:00.0	2013-03-02 08:12:00.0	2	30
TRIAGED	2013-03-02 08:08:00.0	2013-03-02 08:10:00.0	2	30

Showing 1 to 12 of 12 entries

Overall Duration: 3 hours 1 mins

Care Process
Near Real-Time Dashboard

Filter By:

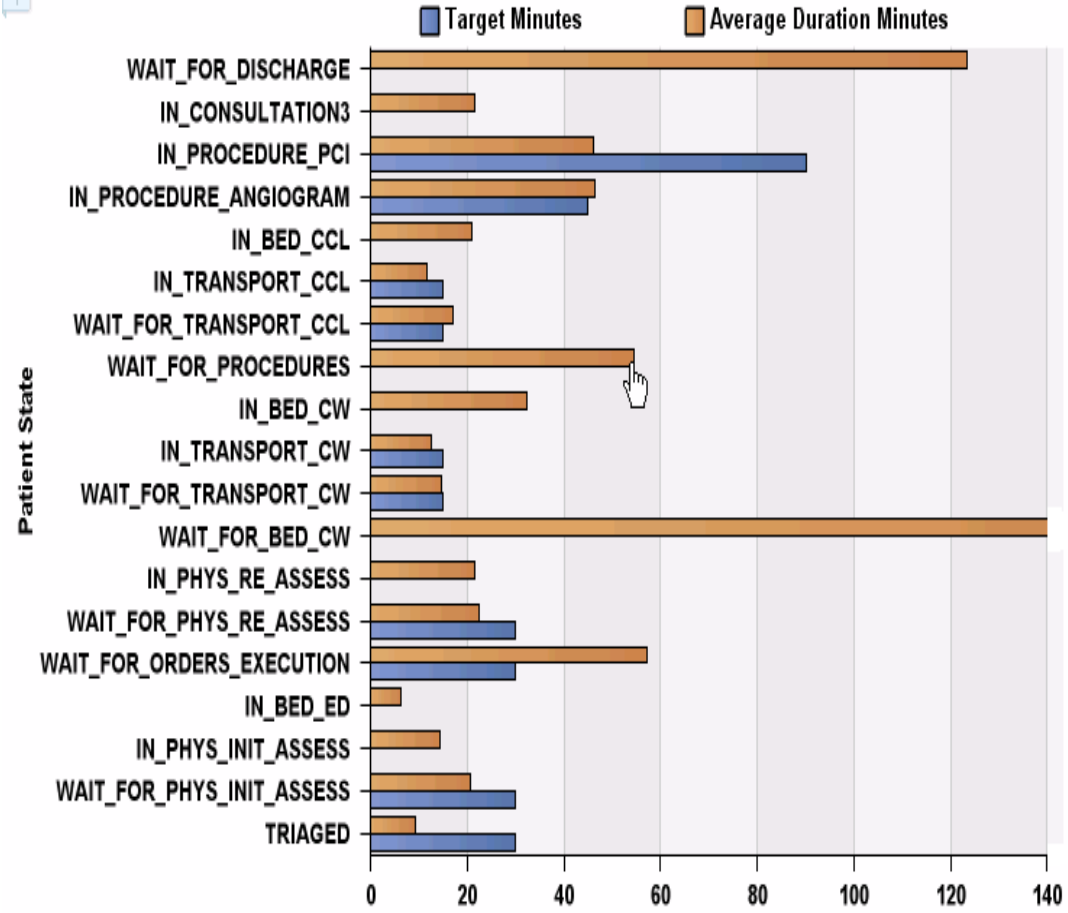
Unit

Unit

CCL
CW
ED

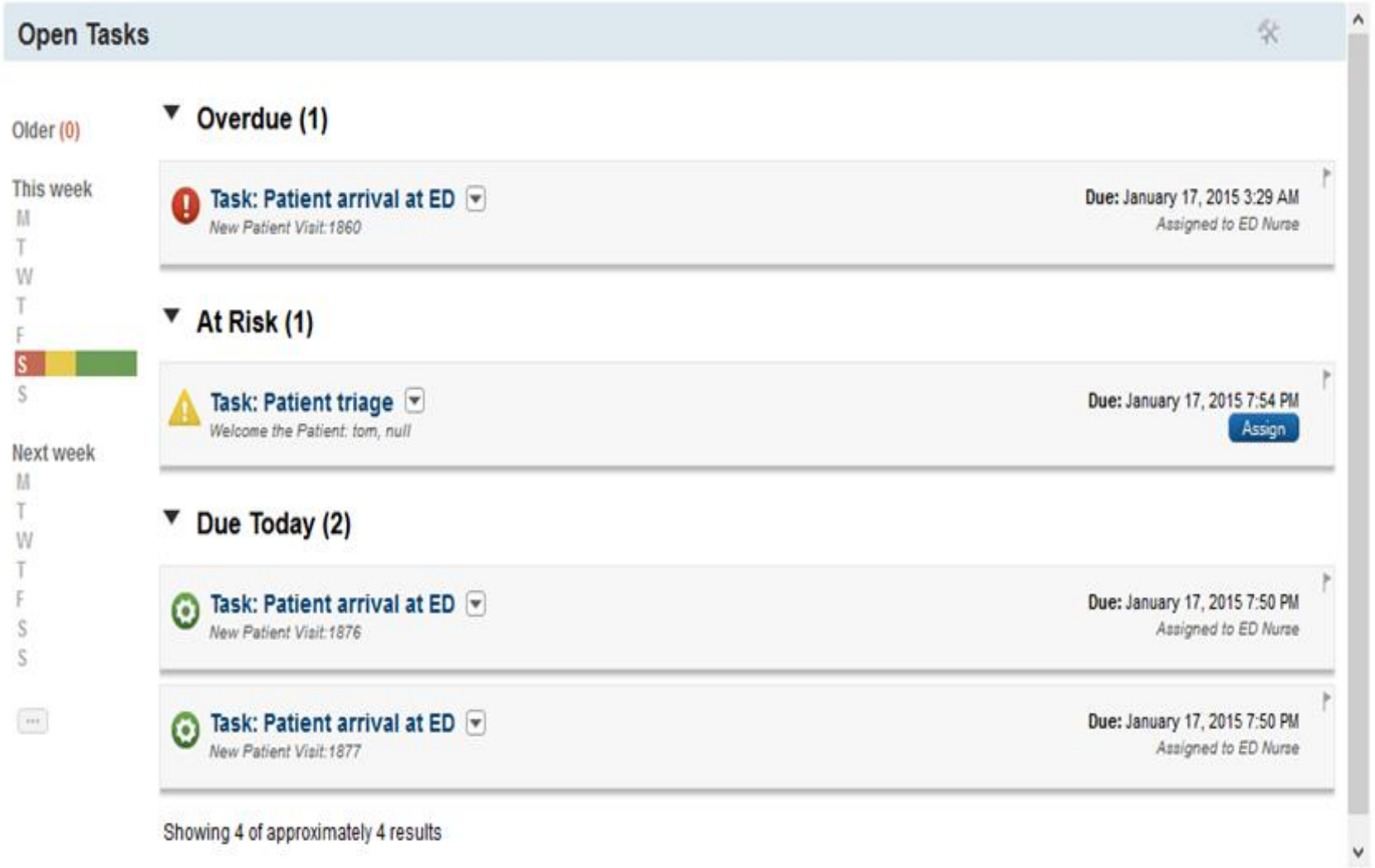
Patient Status

Active
Inactive

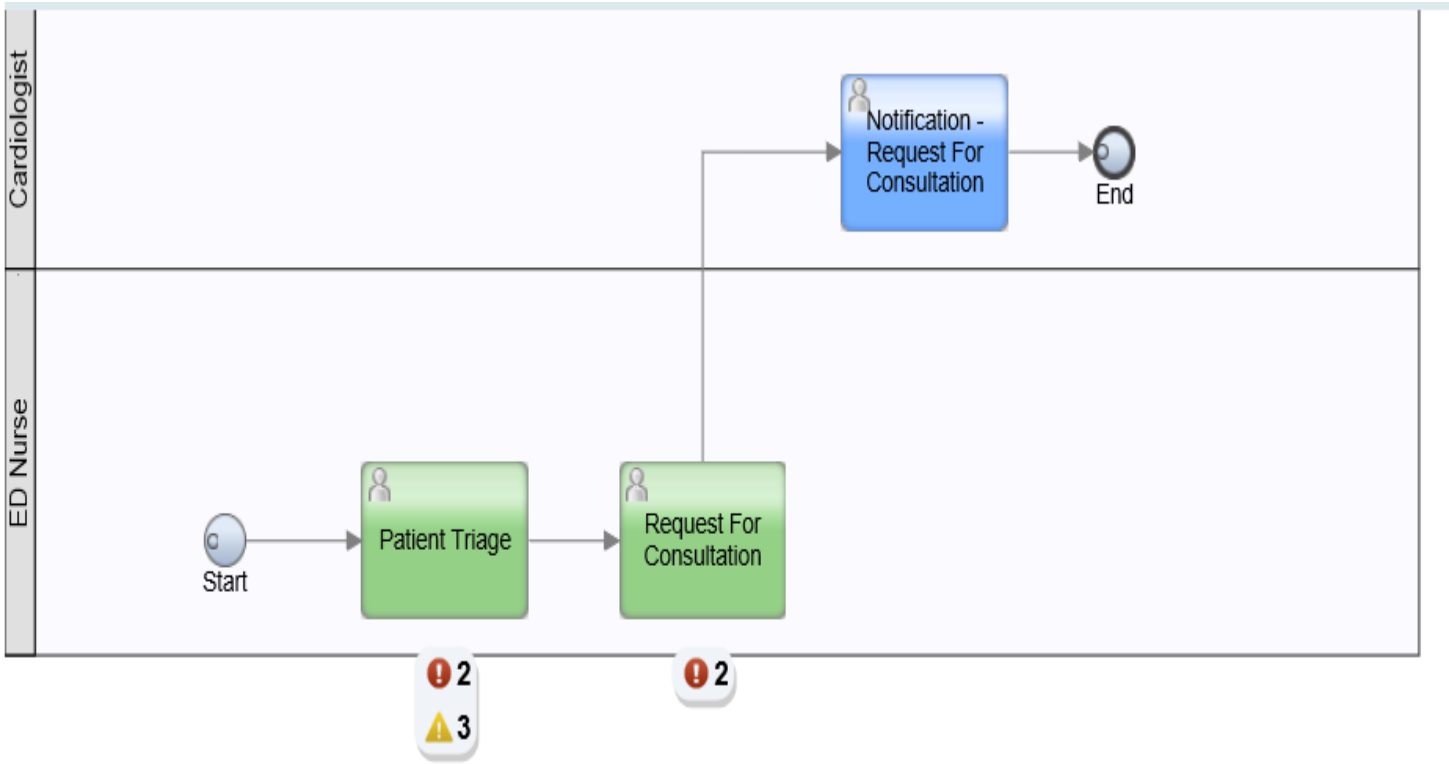


State Name	Average State Duration	Target Duration
Triaged	9 minutes	30 minutes
Wait For Physician Initial Assessment	20 minutes	30 minutes
In Physician Initial Assessment	14 minutes	0 minutes
In Bed ED	6 minutes	0 minutes
Wait For Orders Execution	57 minutes	30 minutes
Wait For Physician Re-Assessment	22 minutes	30 minutes
In Physician Re-Assessment	21 minutes	0 minutes
Wait For Bed CW	10 minutes	0 minutes
Wait For Transport CW	14 minutes	15 minutes
In Transport CW	12 minutes	15 minutes
In Bed CW	32 minutes	0 minutes
Wait For Procedures	54 minutes	0 minutes
Wait For Transport CCL	16 minutes	15 minutes
In Transport CCL	11 minutes	15 minutes
In Bed CCL	21 minutes	0 minutes
In Procedure Angiogram	46 minutes	45 minutes
In Procedure PCI	46 minutes	1 hour 30 minutes
In Consultation 3	21 minutes	0 minutes
Wait For Discharge	2 hours 3 minutes	0 minutes

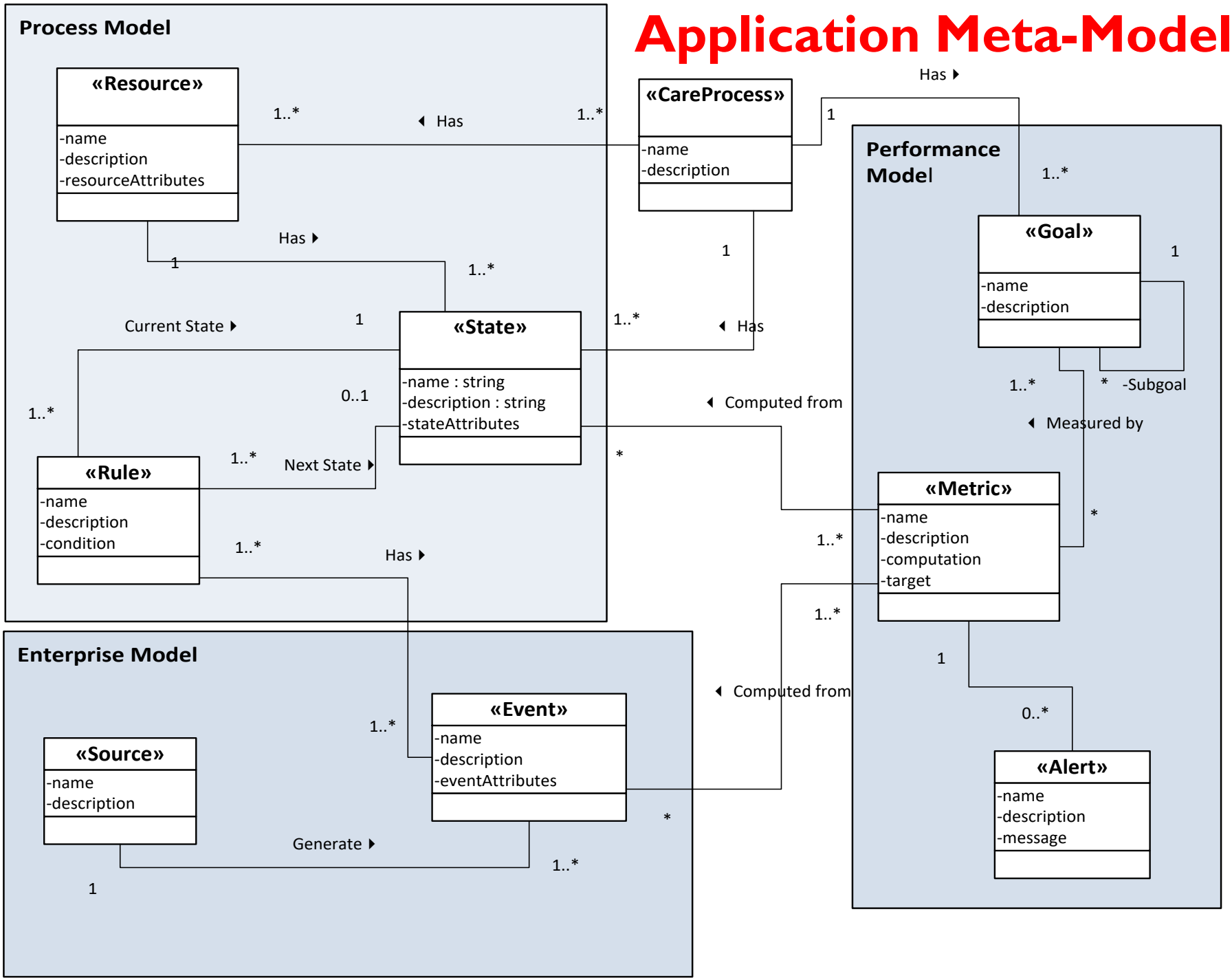
Nurse Prioritized Task Based Report



Process Status Based Report (Bottle Necks)



Application Meta-Model



Norway Intromat Project: Schizofreni Process Mining

Intromat Project
https://intromat.no/

INTROMAT (INtroducing personalized TReatment Of Mental health problems using AdaptiveTechnology)

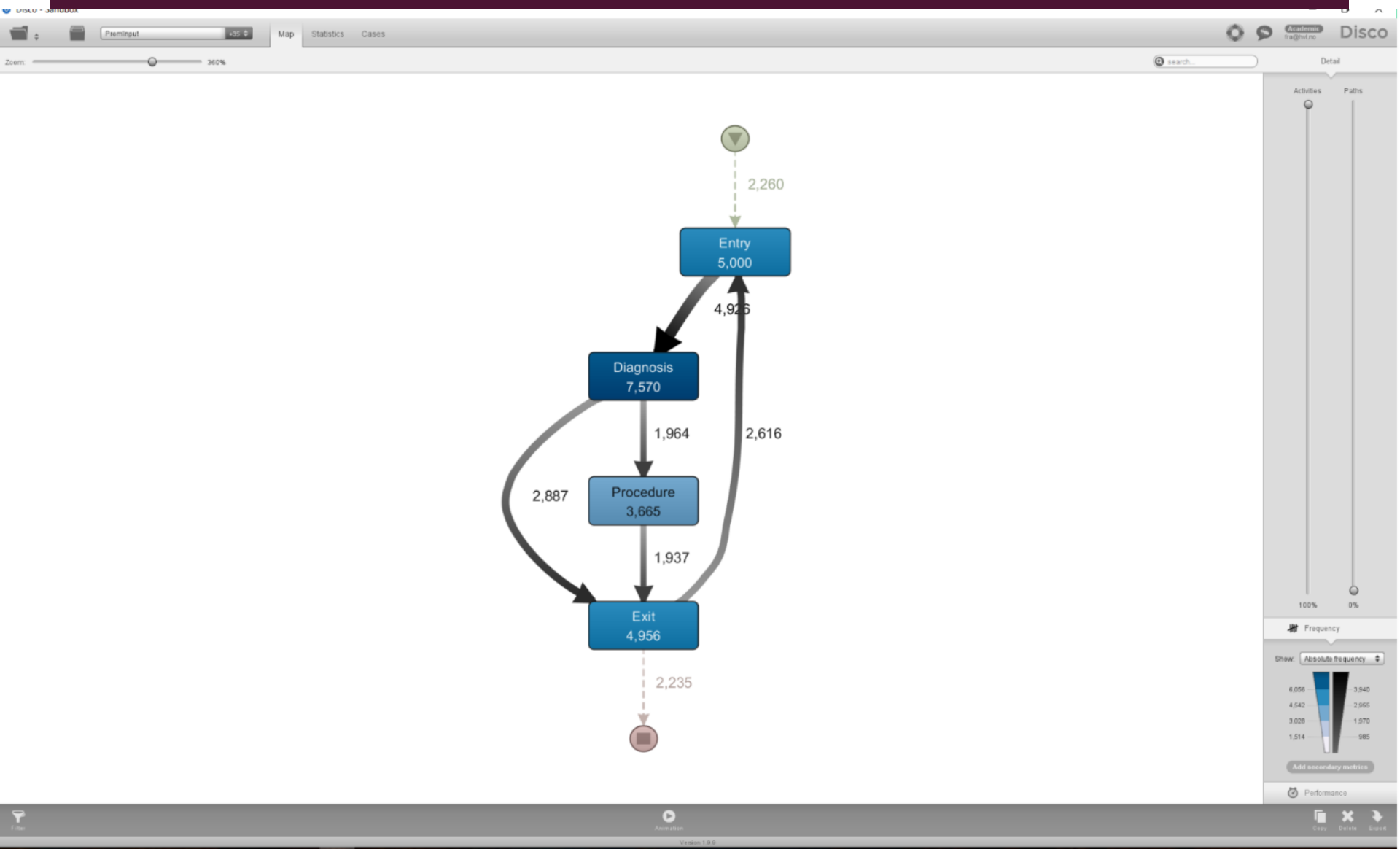
Appointed by The Norwegian Research Council as one of three projects chosen in their IKTPLUSS Lighthouse call.

Improve public mental health with innovative ICT.

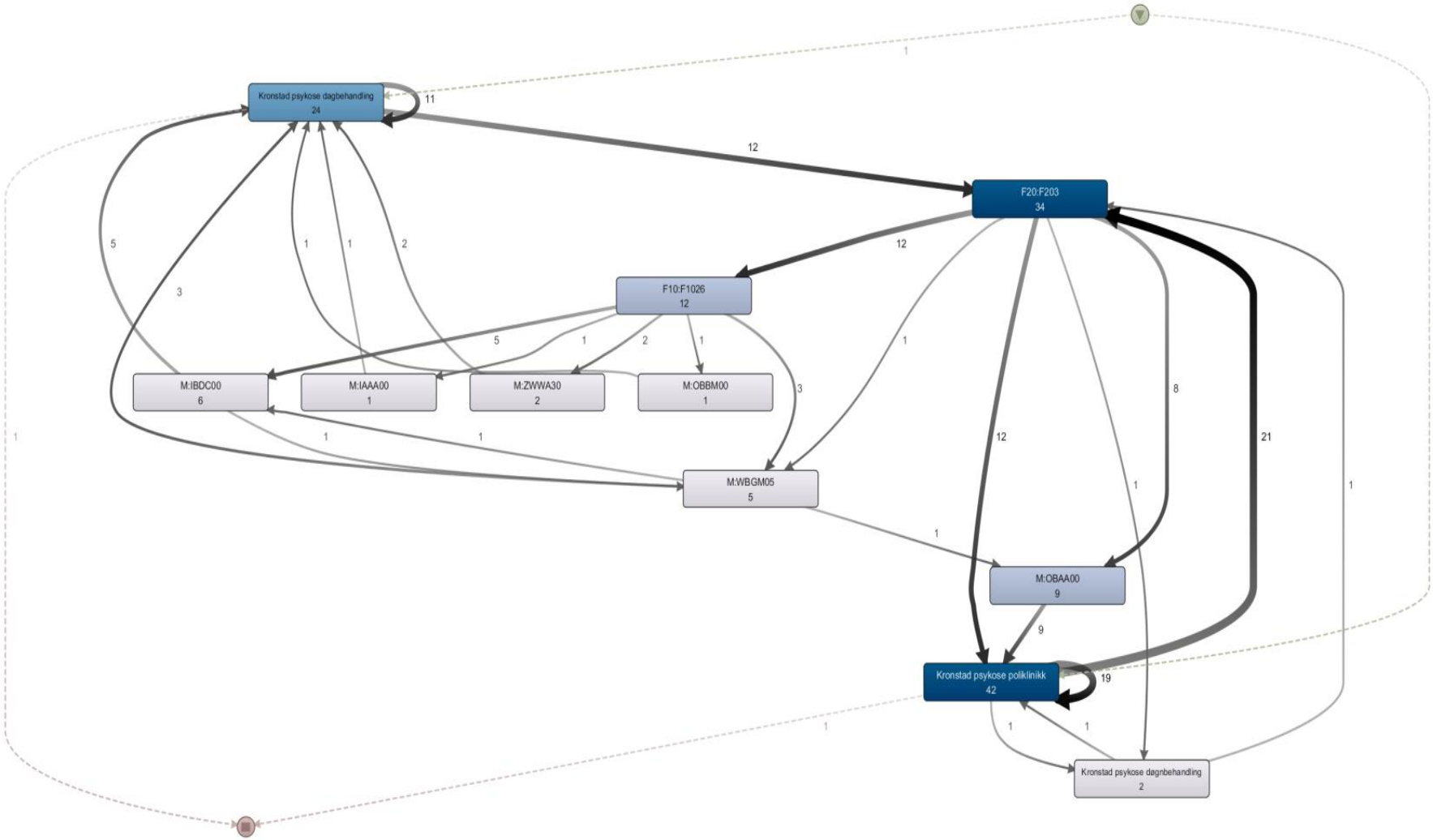
INTROMAT Investigation: Reverse engineering a care process Mental Health: Schizophreni

- **Existing data**
  - Hospital wide database of patient encounters used for billing events 2005-2015
  - Psychiatry specific database of more detailed care data 2005-2015 including blood samples, medications, demographics etc.
- **New Technology – Process Mining**
  - Analyzes sequences of events to identify process patterns
  - Used to identify bottlenecks, quality control issues
  - Could it be used to understand and characterize schizophrenia care?
  - Could the insights be used to reduce relapse episodes requiring acute care intervention
  - Could it be used to meet government mandated SLA agreements ?
- **Approach**
  - Extract hospital Consult Events: Enter Unit, Diagnosis Procedure, Exit Unit
  - If analysis shows promise, extend to include Psychiatry database

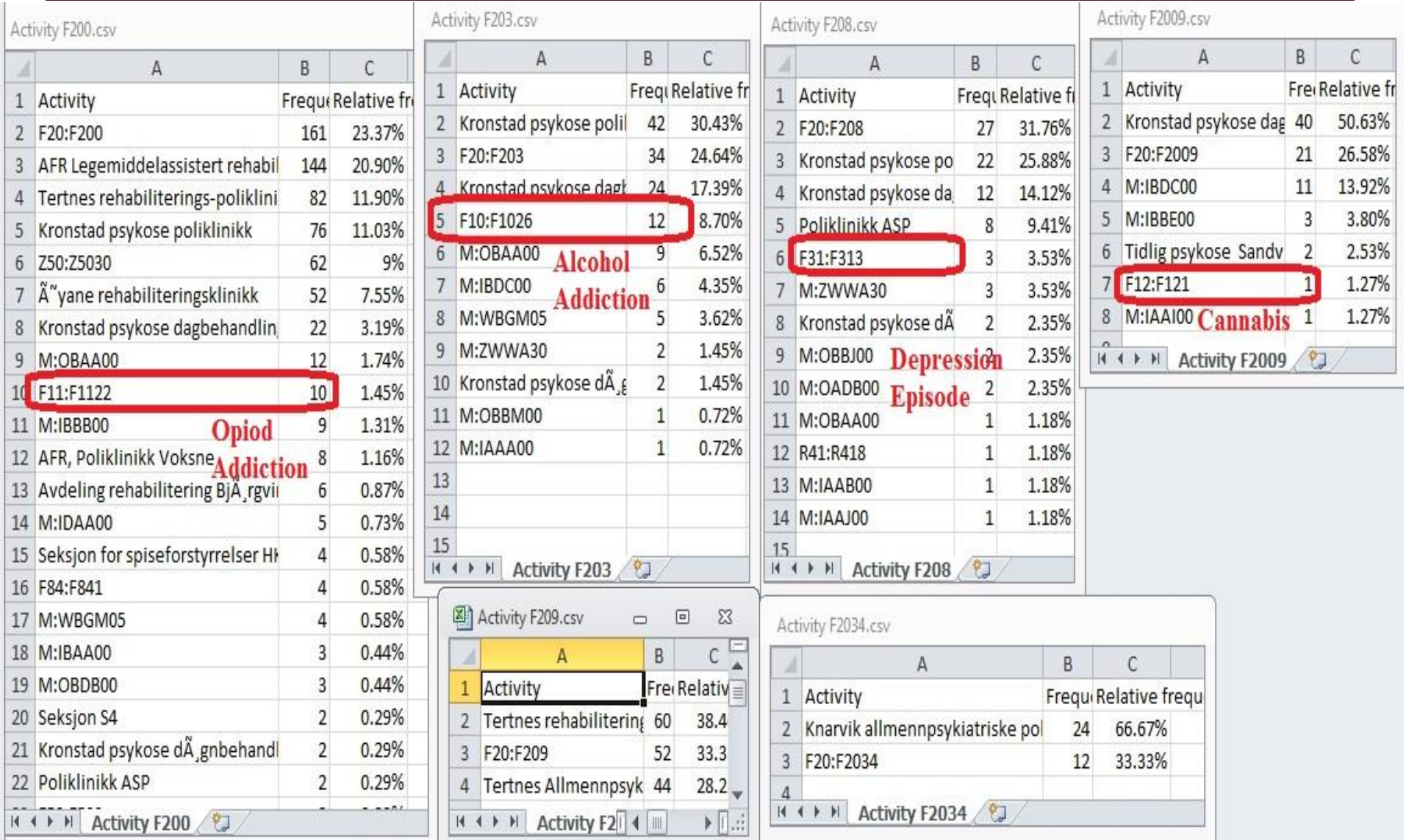
High level view of Hospital Process



Filter on Schizofreni Diagnosis code F203 (34 encounters) Shows a Cluster of Companion Alcohol Diagnosis F1026 (12)



Frequency of Activities (Unit, Diagnosis, Procedure) for the 6 Schizofreni Diagnosis Codes



Activity F200.csv

	A	B	C
1	Activity	Frequ	Relative fr
2	F20:F200	161	23.37%
3	AFR Legemiddelassistert rehabil	144	20.90%
4	Tertnes rehabiliterings-poliklini	82	11.90%
5	Kronstad psykose poliklinikk	76	11.03%
6	Z50:Z5030	62	9%
7	Ã˜yane rehabiliteringsklinikk	52	7.55%
8	Kronstad psykose dagbehandlin	22	3.19%
9	M:OBAA00	12	1.74%
10	F11:F1122	10	1.45%
11	M:IBBB00	9	1.31%
12	AFR, Poliklinikk Voksne	8	1.16%
13	Avdeling rehabilitering BjÃ¸rgvi	6	0.87%
14	M:IDAA00	5	0.73%
15	Seksjon for spiseforstyrrelser HI	4	0.58%
16	F84:F841	4	0.58%
17	M:WBGM05	4	0.58%
18	M:IBAA00	3	0.44%
19	M:OBDB00	3	0.44%
20	Seksjon S4	2	0.29%
21	Kronstad psykose dÃ¸gnbehandl	2	0.29%
22	Poliklinikk ASP	2	0.29%

Opiod Addiction

Activity F203.csv

	A	B	C
1	Activity	Freq	Relative fr
2	Kronstad psykose polil	42	30.43%
3	F20:F203	34	24.64%
4	Kronstad psykose dagb	24	17.39%
5	F10:F1026	12	8.70%
6	M:OBAA00	9	6.52%
7	M:IBDC00	6	4.35%
8	M:WBGM05	5	3.62%
9	M:ZWWA30	2	1.45%
10	Kronstad psykose dÃ¸g	2	1.45%
11	M:OBBM00	1	0.72%
12	M:IAAA00	1	0.72%
13			
14			
15			

Alcohol Addiction

Activity F208.csv

	A	B	C
1	Activity	Freq	Relative f
2	F20:F208	27	31.76%
3	Kronstad psykose po	22	25.88%
4	Kronstad psykose da	12	14.12%
5	Poliklinikk ASP	8	9.41%
6	F31:F313	3	3.53%
7	M:ZWWA30	3	3.53%
8	Kronstad psykose dÃ	2	2.35%
9	M:OBBJ00	2	2.35%
10	M:OADB00	2	2.35%
11	M:OBAA00	1	1.18%
12	R41:R418	1	1.18%
13	M:IAAB00	1	1.18%
14	M:IAAJ00	1	1.18%
15			

Depression Episode

Activity F2009.csv

	A	B	C
1	Activity	Fre	Relative fr
2	Kronstad psykose dag	40	50.63%
3	F20:F2009	21	26.58%
4	M:IBDC00	11	13.92%
5	M:IBBE00	3	3.80%
6	Tidlig psykose Sandv	2	2.53%
7	F12:F121	1	1.27%
8	M:IAAI00	1	1.27%

Cannabis

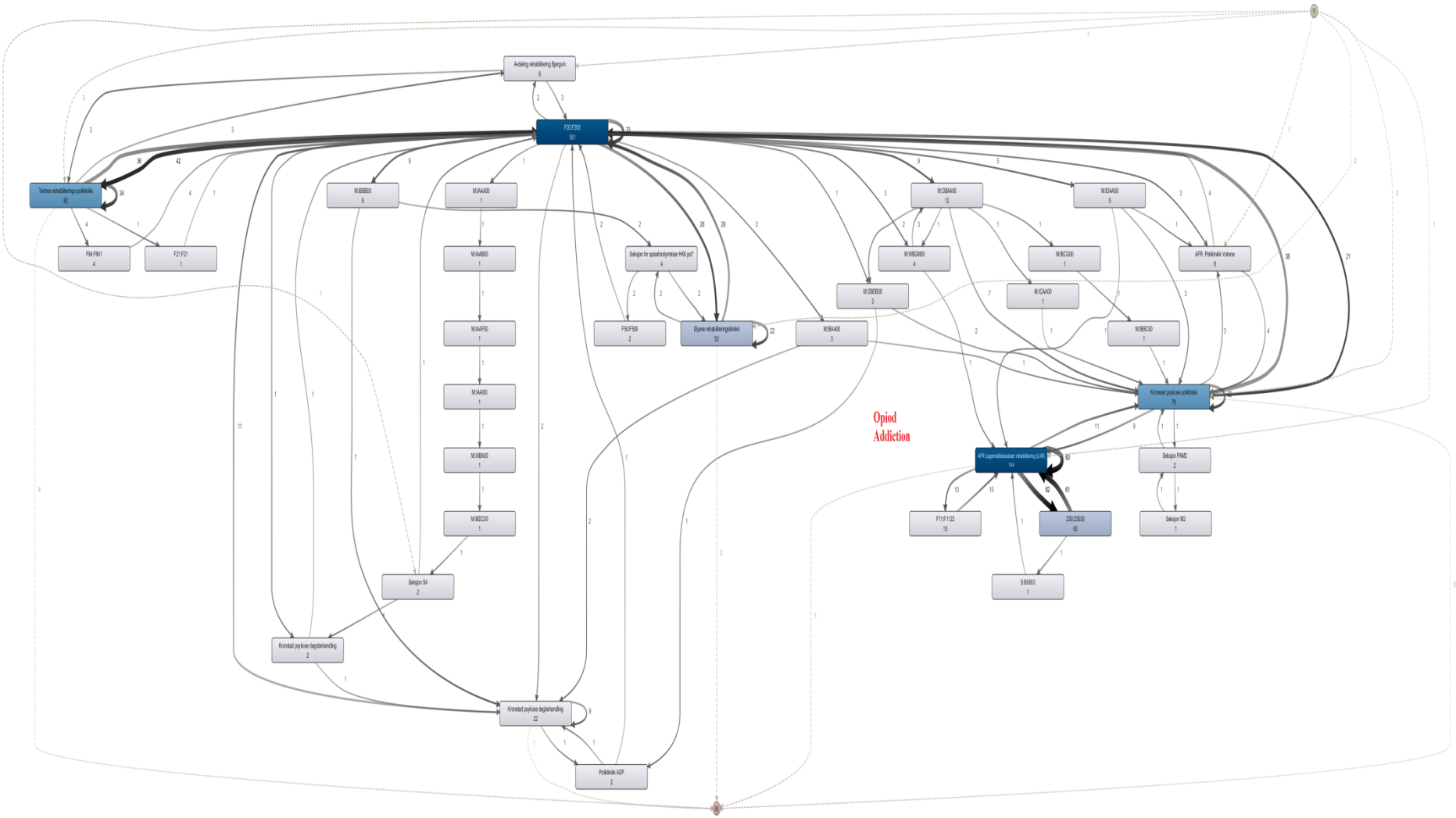
Activity F209.csv

	A	B	C
1	Activity	Fre	Relativ
2	Tertnes rehabiliterin	60	38.4
3	F20:F209	52	33.3
4	Tertnes Allmennpsyk	44	28.2

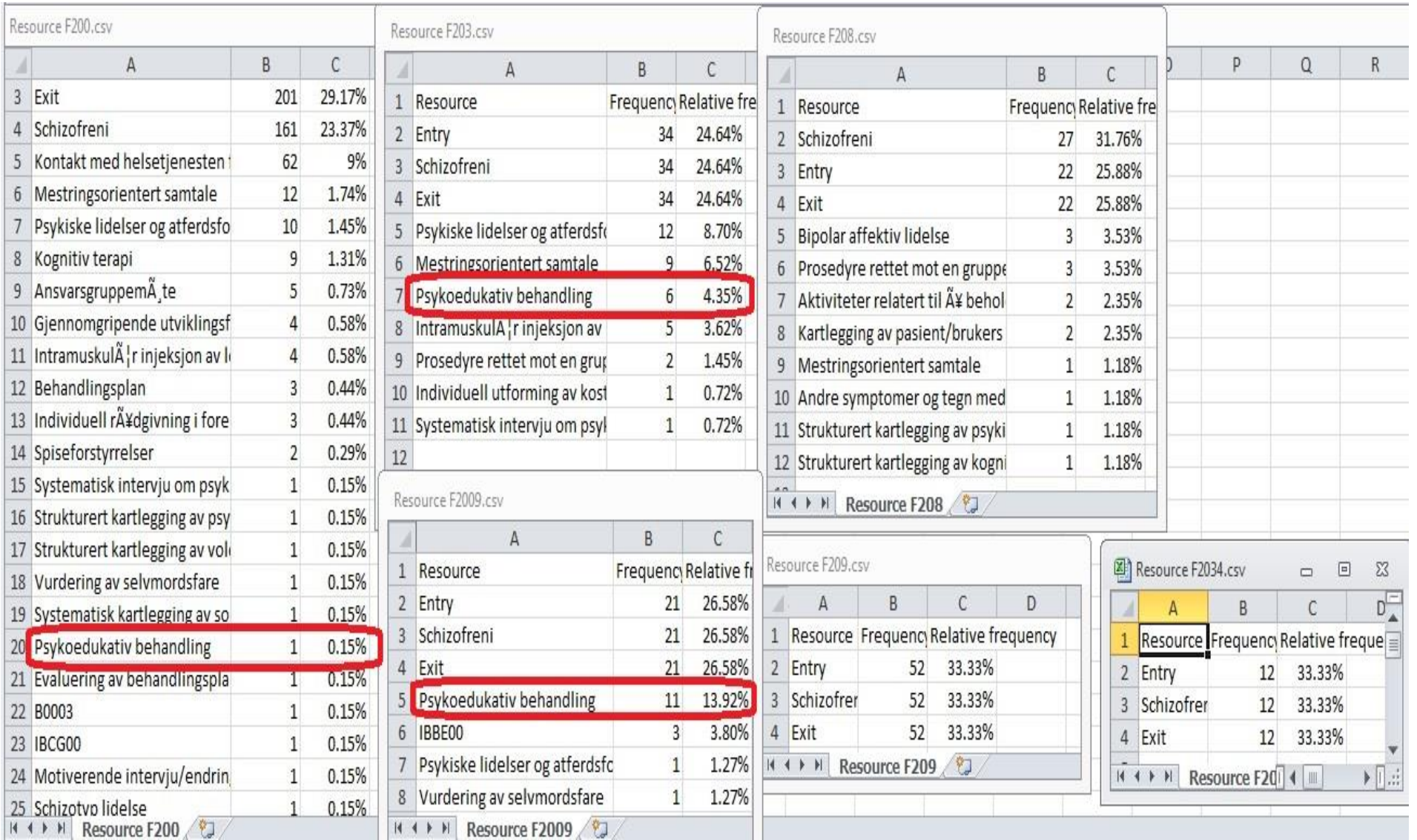
Activity F2034.csv

	A	B	C
1	Activity	Frequ	Relative frequ
2	Knarvik allmennpsykiatriske pol	24	66.67%
3	F20:F2034	12	33.33%
4			

Most Common Schizofreni Diagnosis Code (161) with Opiod Cluster (10)



Resource Usage: Pyscheducative Training for Alcohol and Cannabis only?



Resource F200.csv

	A	B	C
3	Exit	201	29.17%
4	Schizofreni	161	23.37%
5	Kontakt med helsetjenesten	62	9%
6	Mestringsorientert samtale	12	1.74%
7	Psykiske lidelser og atferdsfo	10	1.45%
8	Kognitiv terapi	9	1.31%
9	AnsvarsgruppemÃ¸te	5	0.73%
10	Gjennomgripende utviklingsf	4	0.58%
11	IntramuskulÃ¦r injeksjon av l	4	0.58%
12	Behandlingsplan	3	0.44%
13	Individuell rÃ¥dgivning i fore	3	0.44%
14	Spiseforstyrrelser	2	0.29%
15	Systematisk intervju om psyk	1	0.15%
16	Strukturert kartlegging av psy	1	0.15%
17	Strukturert kartlegging av vol	1	0.15%
18	Vurdering av selvmordsfare	1	0.15%
19	Systematisk kartlegging av so	1	0.15%
20	Psykoedukativ behandling	1	0.15%
21	Evaluering av behandlingspla	1	0.15%
22	B0003	1	0.15%
23	IBCG00	1	0.15%
24	Motiverende intervju/endrin	1	0.15%
25	Schizotyp lidelse	1	0.15%

Resource F200

Resource F203.csv

	A	B	C
1	Resource	Frequency	Relative fre
2	Entry	34	24.64%
3	Schizofreni	34	24.64%
4	Exit	34	24.64%
5	Psykiske lidelser og atferdsfc	12	8.70%
6	Mestringsorientert samtale	9	6.52%
7	Psykoedukativ behandling	6	4.35%
8	IntramuskulÃ¦r injeksjon av	5	3.62%
9	Prosedyre rettet mot en grup	2	1.45%
10	Individuell utforming av kost	1	0.72%
11	Systematisk intervju om psyk	1	0.72%
12			

Resource F2009.csv

	A	B	C
1	Resource	Frequency	Relative fr
2	Entry	21	26.58%
3	Schizofreni	21	26.58%
4	Exit	21	26.58%
5	Psykoedukativ behandling	11	13.92%
6	IBBE00	3	3.80%
7	Psykiske lidelser og atferdsfc	1	1.27%
8	Vurdering av selvmordsfare	1	1.27%

Resource F2009

Resource F208.csv

	A	B	C
1	Resource	Frequency	Relative fre
2	Schizofreni	27	31.76%
3	Entry	22	25.88%
4	Exit	22	25.88%
5	Bipolar affektiv lidelse	3	3.53%
6	Prosedyre rettet mot en gruppe	3	3.53%
7	Aktiviteter relatert til Ã¥ behol	2	2.35%
8	Kartlegging av pasient/brukers	2	2.35%
9	Mestringsorientert samtale	1	1.18%
10	Andre symptomer og tegn med	1	1.18%
11	Strukturert kartlegging av psyki	1	1.18%
12	Strukturert kartlegging av kogni	1	1.18%

Resource F208

Resource F209.csv

	A	B	C	D
1	Resource	Frequency	Relative frequency	
2	Entry	52	33.33%	
3	Schizofrer	52	33.33%	
4	Exit	52	33.33%	

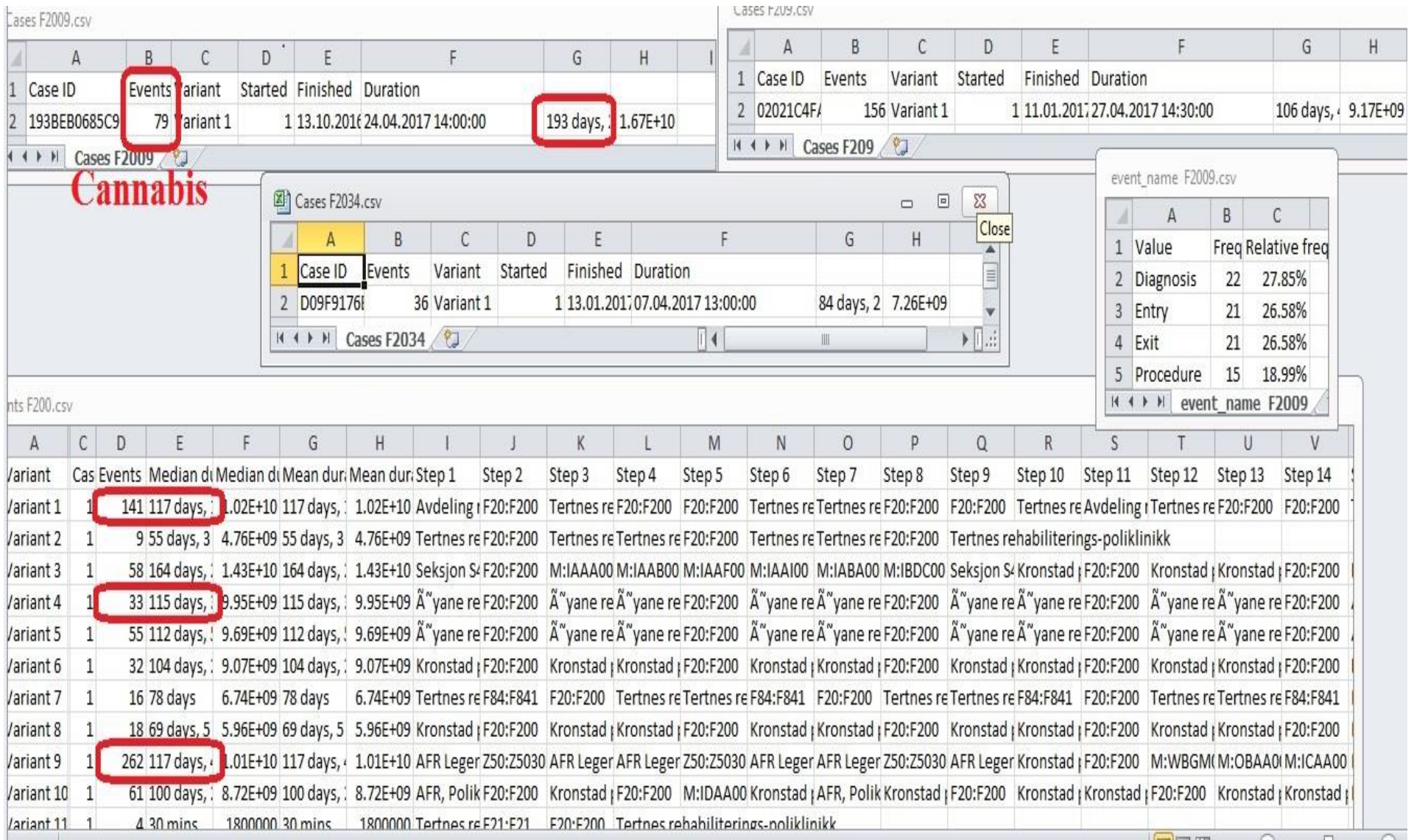
Resource F209

Resource F2034.csv

	A	B	C	D
1	Resource	Frequency	Relative freque	
2	Entry	12	33.33%	
3	Schizofrer	12	33.33%	
4	Exit	12	33.33%	

Resource F20

Measures Number of Events per Patient and Duration
Co-Morbidity not high frequency but Cannabis long duration



Next Steps

- **Understand and Pre-Process Data Better**
  - **Consults with Epicrisis** (not all Patient Activity as one event stream)
  - **Define relapse episode**
  - Adjust filters to right mix of events, consults
- **Process mining Community**
  - **https://fluxicon.com/disco/**
  - **http://www.processmining.org/**
  - **http://www.padsweb.rwth-aachen.de/wvdaalst/**
- **Provide additional tool support** for dimensional analysis, clustering , and anomaly detection(demographics, medications, blood work etc.)
- Define consensus on core process steps and SLA and Indicators **(Dashboard)**
- Extend to other mental health (depression, anxiety, ADHD, …)