LINKED DATA AND PROCESS MINING:

Identifying Pre-hospital Retrieval Pathways and Processes for Road Trauma Patients in Queensland

A Study Conducted 2017-19

Professor Moe Thandar Wynn
Professor Arthur ter Hofstede
Professor Kirsten Vallmuur
Dr Robert Andrews
Assoc. Professor Emma Bosley
Dr Stephen Rashford
Dr Mark Elcock

BUSINESS PROCESS MANAGEMENT GROUP

QUT

PROCESSES AND PROCESS MINING

- Processes are ubiquitous
  - a set of steps designed to achieve a goal
  - process steps are carried out in an order
    - Some steps can't happen before a previous step has completed
    - Some steps can happen while other steps are happening
  - process steps are carried out by an agent – person, machine, IT system
  - process steps are carried out at given time
  - process steps are recorded in IT systems
- Structured processes
  - rigorously defined with an end-to-end model, that takes into account all the process instance permutations. No process instance can stray from process model
- Unstructured processes
  - every process instance can be different
- Structured --- *Medical* ---- Unstructured

check-In

Exam

Retrieve Medical Record

Follow-Up

https://www.foreseemed.com/hospital-workflows

2

PROCESS MINING = DATA MINING + PROCESS MANAGEMENT + VISUALISATION

Case ID	Activity	Complete Timestamp
19:115933	Start	10/02/2010 13:45
19:115933	Ambulance transportation	10/02/2010 13:45
19:115933	ED Presentation	10/02/2010 13:55
19:115933	ED Presentation, Triage Category	10/02/2010 13:55
19:115933	Attended to in ED	10/02/2010 13:55
19:115933	ED P Diag: Chest Pain	10/02/2010 13:55
19:115933	Admitted to a Clinical Unit (inpat	10/02/2010 17:44
19:115933	Admitted to Medical	10/02/2010 17:44
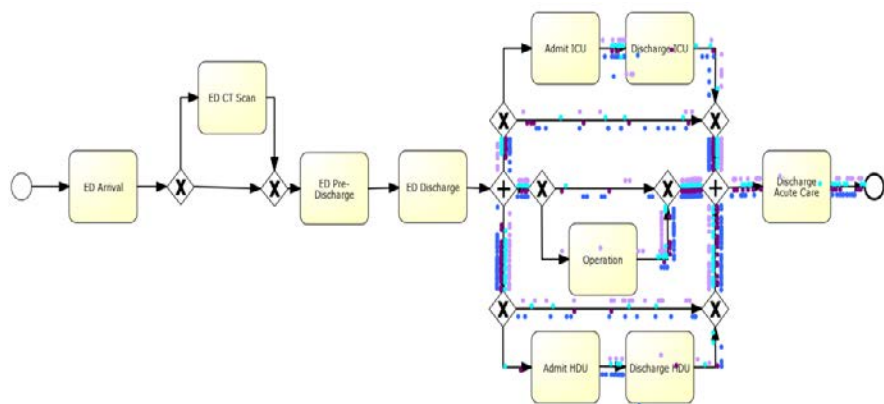
**Automated process discovery** - *What is the actual patient journey?*
**Conformance checking** - *To what extent do we follow clinical guidelines?*
Performance analysis - *Where do unacceptable waiting times occur?*

PROJECT BACKGROUND

- Road accidents happen all across the state (and Qld is BIG!) and road trauma accounts for a big percentage of all trauma patients treated in the Qld Health system.

- Study questions

  - What is the *range of care, retrieval & transport processes* for road trauma patients?

  - What is the degree of conformance (to guidelines) and comparative performance analyses for the different cohorts?

    - What is the level of conformance to *Trauma By-pass Guideline ?*

- Approach

  - *Understand* the process and available data

  - Assess the *quality* of QAS, RSQ, EDC and QHAPDC time/event data

  - *Align* our understanding of the process and data with stakeholders

 - Data extraction, *Linking*, Log generation, and Process modelling
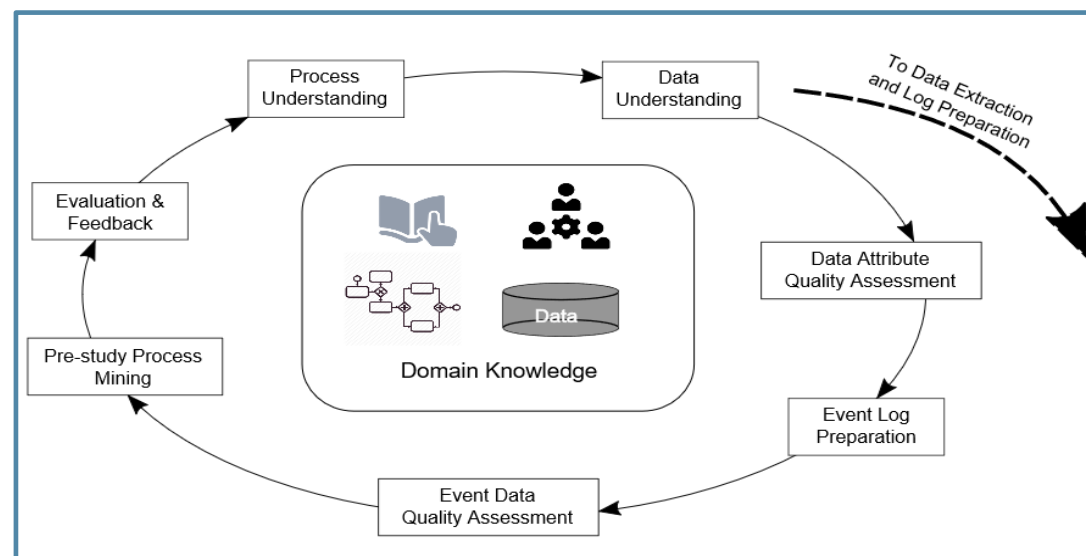
UNDERSTAND THE PROCESS
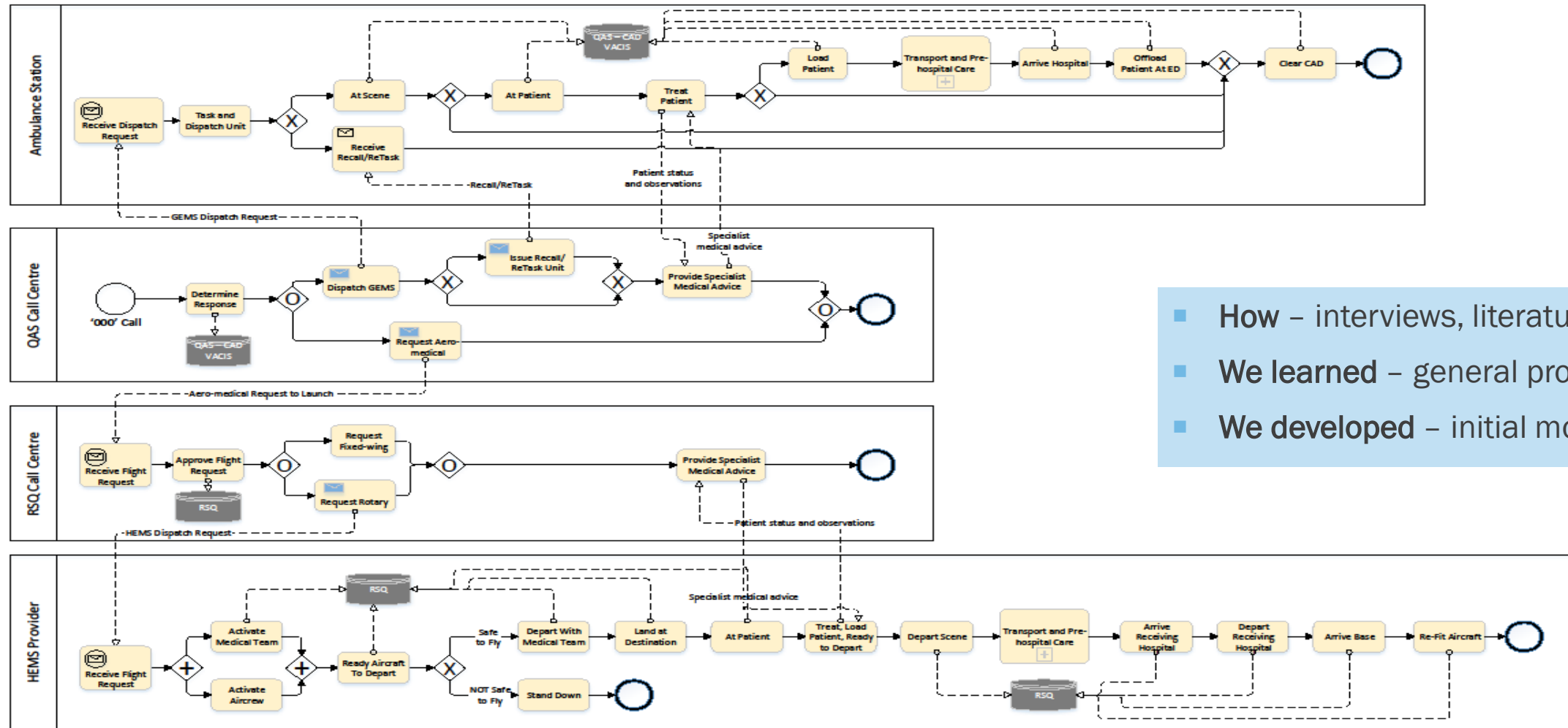
- **How** – interviews, literature
- **We learned** – general process
- **We developed** – initial model

UNDERSTAND THE DATA

- **What is relevant, what is available, from where?**

- **Methods**
  - schema and dictionaries of candidate data sources

- **Outputs**
  - data models (ORM) of QAS and RSQ data
  - PHA and request for data from QAS
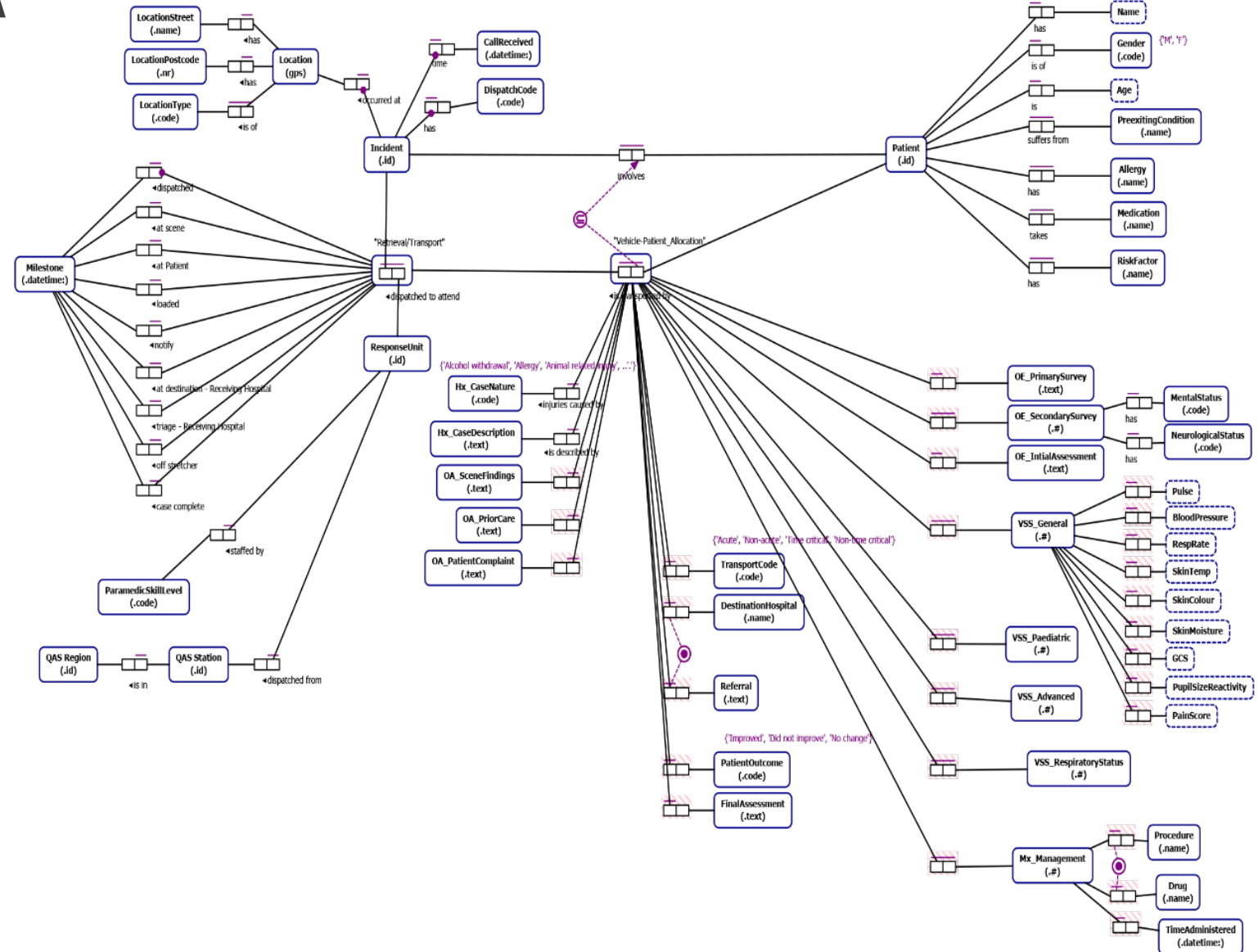
DATA QUALITY ASSESSMENT

- *Garbage in – Garbage out*

- *Multi-dimensional* concept

  - dimension – some measurable aspect of data, e.g. accuracy, completeness, precision, currency, …

  - no single dimension provides an overall view of quality

- Attribute level metrics

  - quality of each dimension can be measured

Column name
T_INCIDENT
D_RECEIVED_CAD
FIRST_ASSIGNED_CA
CAD (Vehicle) Waypoi
ON_SCENE_CAD
DEPART_SCENE_CAD
AT_DEST_CAD
CLEAR_CAD
eARF (Patient) Waypoi
EN_ROUTE_VACIS
AT_SCENE_VACIS
AT_PAT_VACIS
LOADED_VACIS
NOTIFY_VACIS
OFF_STRETCHER_VA

icate effects on ing

mixed (with some ndicates *event* sues

Event Log Builder — QAS1Pat1Vehicle

Case Table - QAS1Pat1Vehicle, Child Table - QAS1Pat1Vehicle

Description:
Primary key: Row count: 243   Number of timestamps: 12
Other unique keys: T_INCIDENT   Table type: BASE TABLE   Child level: 1

Column	Data Type	Event Role	ID	Transition	Accur...	Suffic...	Precis...	Consi...	Comp...	Objec...	Security	Uniqu...	Infor...	Integr...	Conci...	Curre...
T_INCIDENT	int	Case ID			100%	60%			100%			100%	100%	100%	100%	
T_CASE_NO	int				100%	60%			100%			100%	100%	100%	100%	
N_EARF	int	Case Data			100%	60%			100%			100%	100%	100%	100%	
D_RECEIVED_CAD	datetime	Event		complete	100%	60%	83%		100%			100%	100%	100%		60%
D_FIRST_ASSIGNED_CAD	datetime	Event		complete	100%	60%	83%		100%			100%	100%	100%		60%
D_EN_ROUTE_VACIS	datetime	Event		complete	100%	60%	67%	93%				99%	100%	100%		60%
D_AT_SCENE_VACIS	datetime	Event		complete	100%	60%	66%	97%				98%	100%	100%		60%
D_ON_SCENE_CAD	datetime	Event		complete	100%	60%	83%	98%				100%	100%	100%		60%
D_AT_PAT_VACIS	datetime	Event		complete	100%	60%	66%	82%				99%	100%	100%		60%
D_LOADED_VACIS	datetime	Event		complete	100%	60%	66%	53%				100%	100%	100%		60%
D_DEPART_SCENE_CAD	datetime	Event		complete	100%	60%	83%	53%				100%	100%	100%		60%
D_NOTIFY_VACIS	datetime	Event		complete	100%	60%	67%	6%				53%	100%	100%	5%	60%
D_AT_DEST_CAD	datetime	Event		complete	100%	60%	83%	53%				100%	100%	100%		60%
D_OFF_STRETCHER_VACIS	datetime	Event		complete	100%	60%	66%	52%				99%	100%	100%		60%
D_CLEAR_CAD	datetime	Event		complete	100%	60%	83%		100%			100%	100%	100%		60%
T_VEHICLE	int				100%	60%			100%			100%	0%	100%		

Andrews, R., Wynn, M.T., Vallmuur, K., ter Hofstede, A.H.M., Bosley, E., Elcock, M., Rashford, S. Pre-hospital retrieval and transport of road trauma patients in Queensland: A process mining analysis. In 1st International Workshop on Process-Oriented Data Science for Healthcare (PODS4H), 2018, Sydney, N.S.W.

DATA QUALITY ASSESSMENT

- Has both diagnostic (why do these issues occur – people, system, policy) and prognostic (anticipate effects we will see in modelling)

Look Back

Reason about causes, what can be done to fix quality issues

Data Quality Metrics

Look Ahead

Anticipate effects on process mining, e.g. parallelism where there should be sequence

ETL

LOG

Andrews, Robert, Wynn, Moe, Vallmuur, Kirsten, ter Hofstede, Arthur, Bosley, Emma, Elcock, Mark, et al. (2019) Leveraging data quality to better prepare for process mining: An approach illustrated through analysing road trauma pre-hospital retrieval and transport processes in Queensland. International Journal of Environmental Research and Public Health, 16(7), Article number: 11381-25.

STUDY DATA

- All road traffic crash incidents/attendances/transports/hospital encounters between 1/7/2015 and 30/6/2017

    - QAS – **all** 92,420 CAD and eARF data (AMPDS = 29)

    - RSQ – **all** 9,082 transports Jul 2015 to Jun 2017

    - EDC – **all** 32,100 presentations (that could be) matched with QAS transports to Qld Health reporting facilities

    - QHAPDC – **all** 19,462 admissions (that could be) matched with QAS transports to Qld Health reporting facilities

    - Deaths – **all** 371 deaths (that could be) matched with QAS transports to Qld Health reporting facilities

- Observations (at the time of the study):

    - no common patient identifier

        - challenges in linking (approximate, manual matching by DLU) → hinders end-to-end patient journey modelling

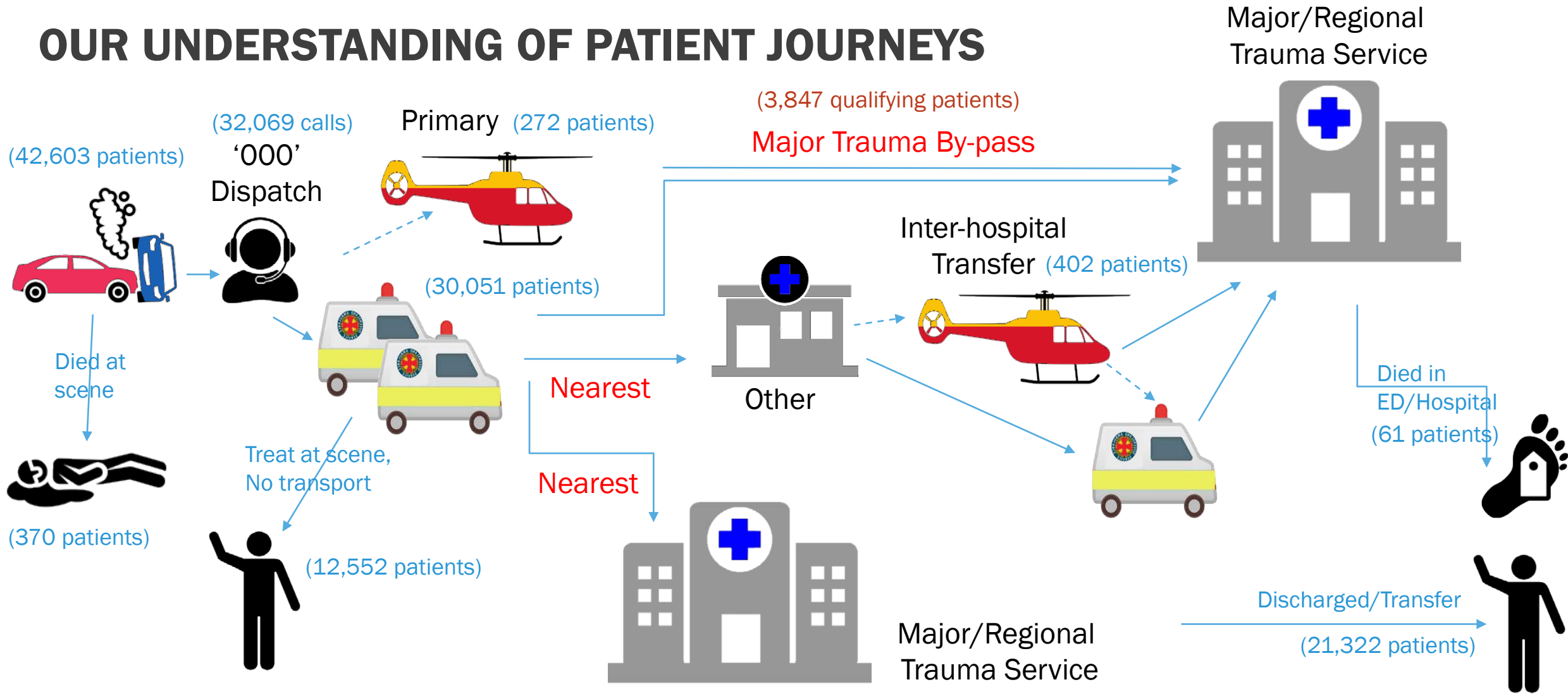   - added to time from request to provision of data
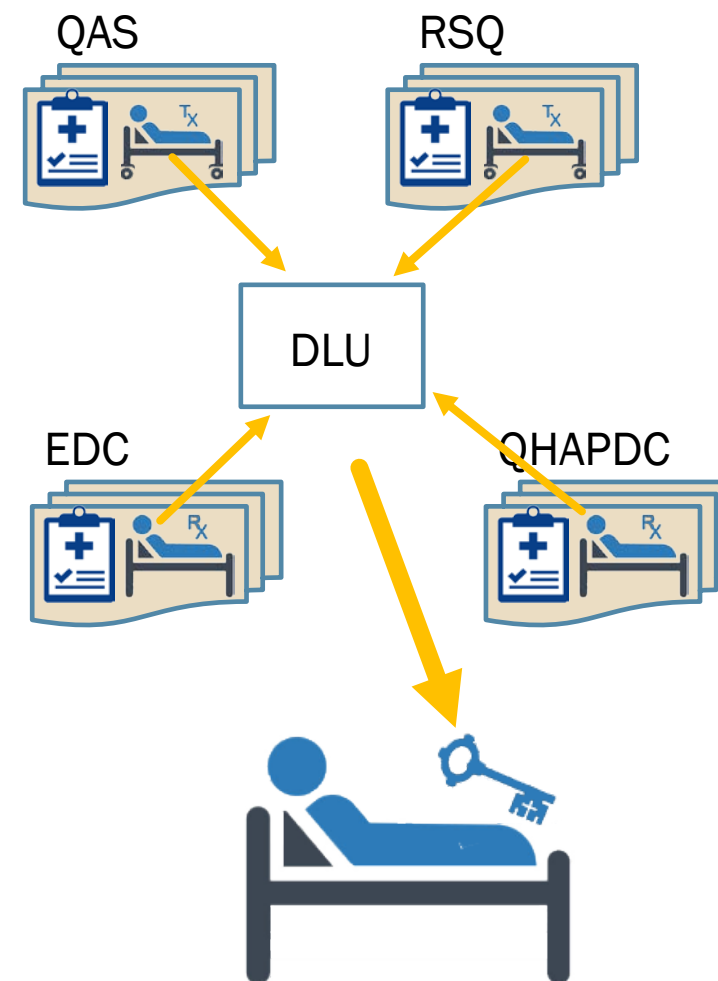
EVENT LOG GENERATION
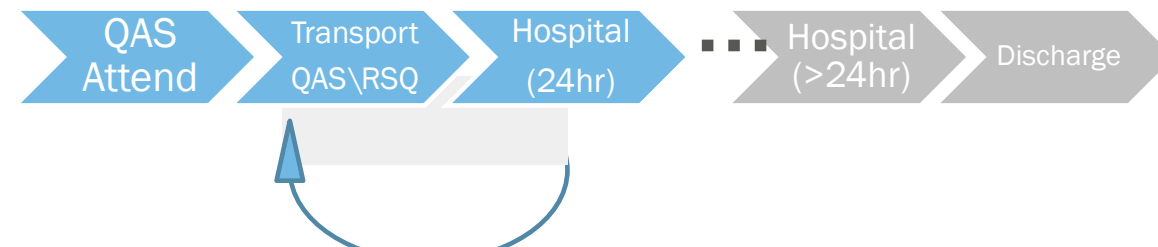
- This cohort represents 51.22% of cases and 72.8% of recorded events

- Large number of trace variants relative to the number of cases, i.e. *complex*

  - Highly variable process execution

    - interleaving of events, e.g. HOSPITAL_ADMIT can occur at various points while the patient is in ED

    - incorrect sequencing due to mixed timestamp granularity

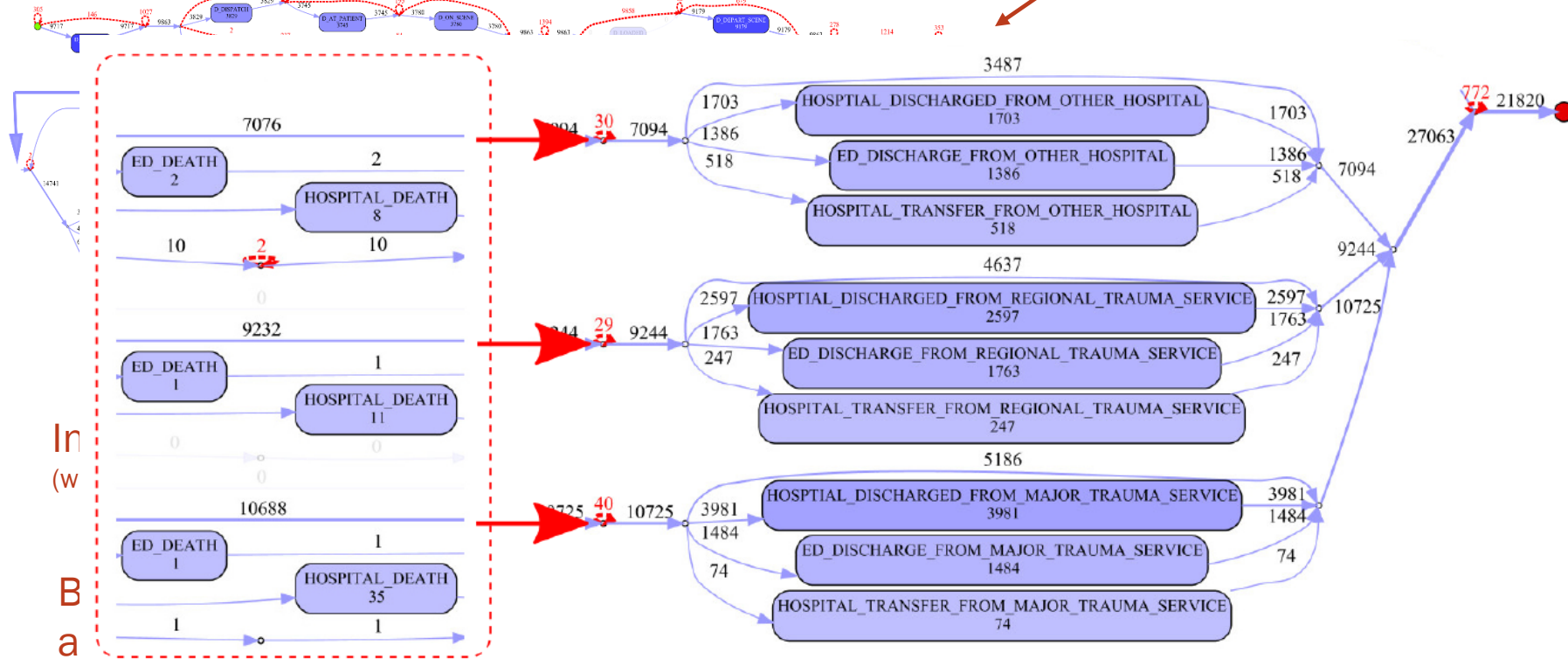   - multiple responding units

    - Inter-hospital transfers

Number of cases	21,820
Number of (trace) variants	2,800
Start date	01/07/2015 05:38:13 AEST
End date	06/07/2017 14:52:00 AEST
Case duration (min)	53 mins 26 secs
Case duration (max)	7 days, 23 hours
Case duration (median)	14.9 hours
Case duration (mean)	35.1 hrs
Number of events	132,447
Events per case (min)	5
Events per case (max)	45
Events per case (median)	13
Events per case (mean)	12.25

OUR UNDERSTANDING OF PATIENT JOURNEYS

(42,603 patients)

(32,069 calls)
'000' Dispatch

Primary (272 patients)

(3,847 qualifying patients)
Major Trauma By-pass

Major/Regional Trauma Service

Inter-hospital Transfer (402 patients)

Died at scene

(30,051 patients)

Nearest

Other

(370 patients)

Treat at scene, No transport

Nearest

Died in ED/Hospital (61 patients)

(12,552 patients)

Major/Regional Trauma Service

Discharged/Transfer

(21,322 patients)

Process Mining Outcomes - *Discovery*

Attend/transport activities

In...
(w...

B...
a...

service level
- Other
- Regional TS
- Major TS

- IHT originate mainly other (62%) or RTS (29%)
- Relatively few deaths in ED/Hospital

Patient Outcomes
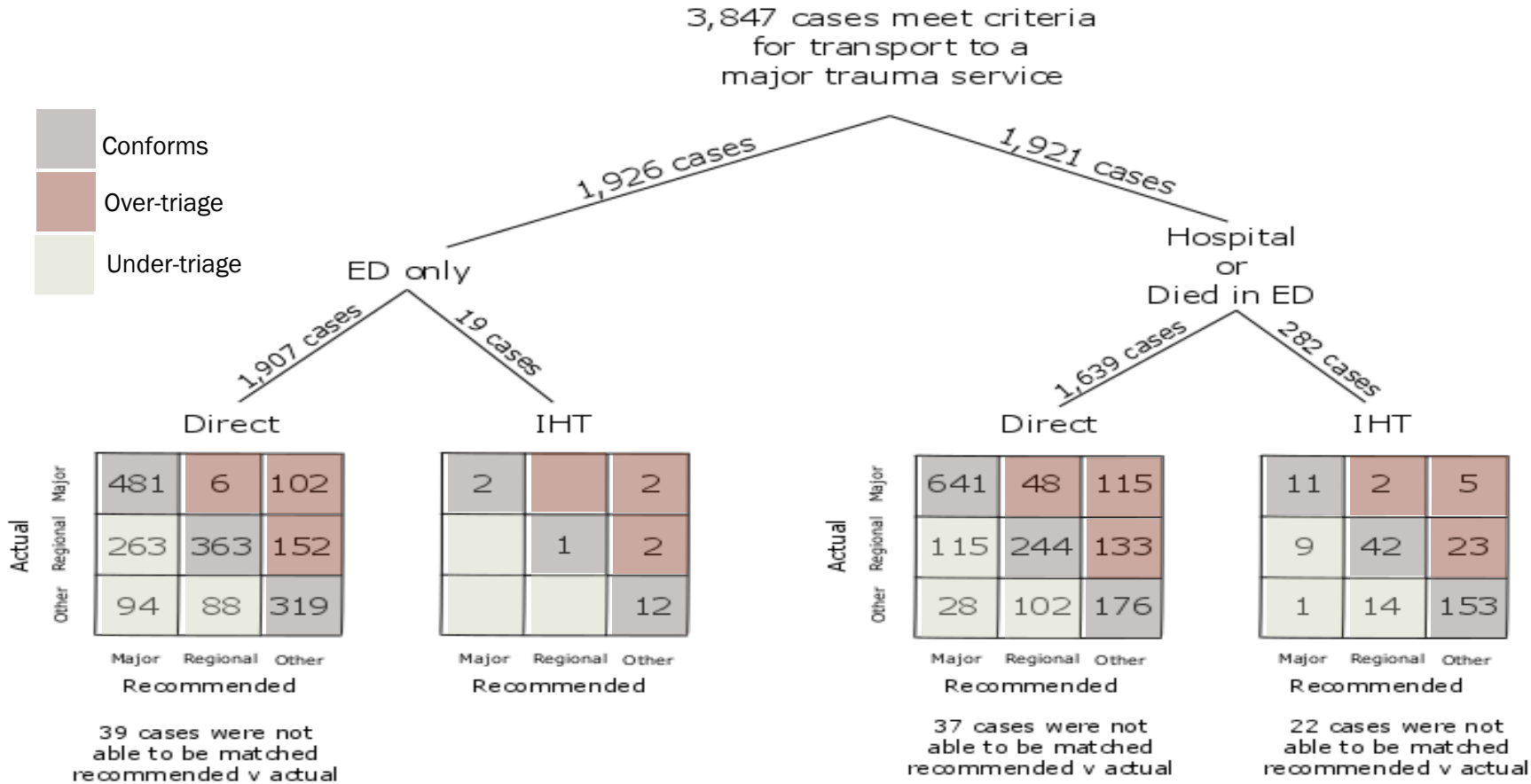Death or Transfer/Discharge

Process Mining Outcomes - *Performance by Transport Segment*

Initial Attend and Transport

Inter-hospital Transport
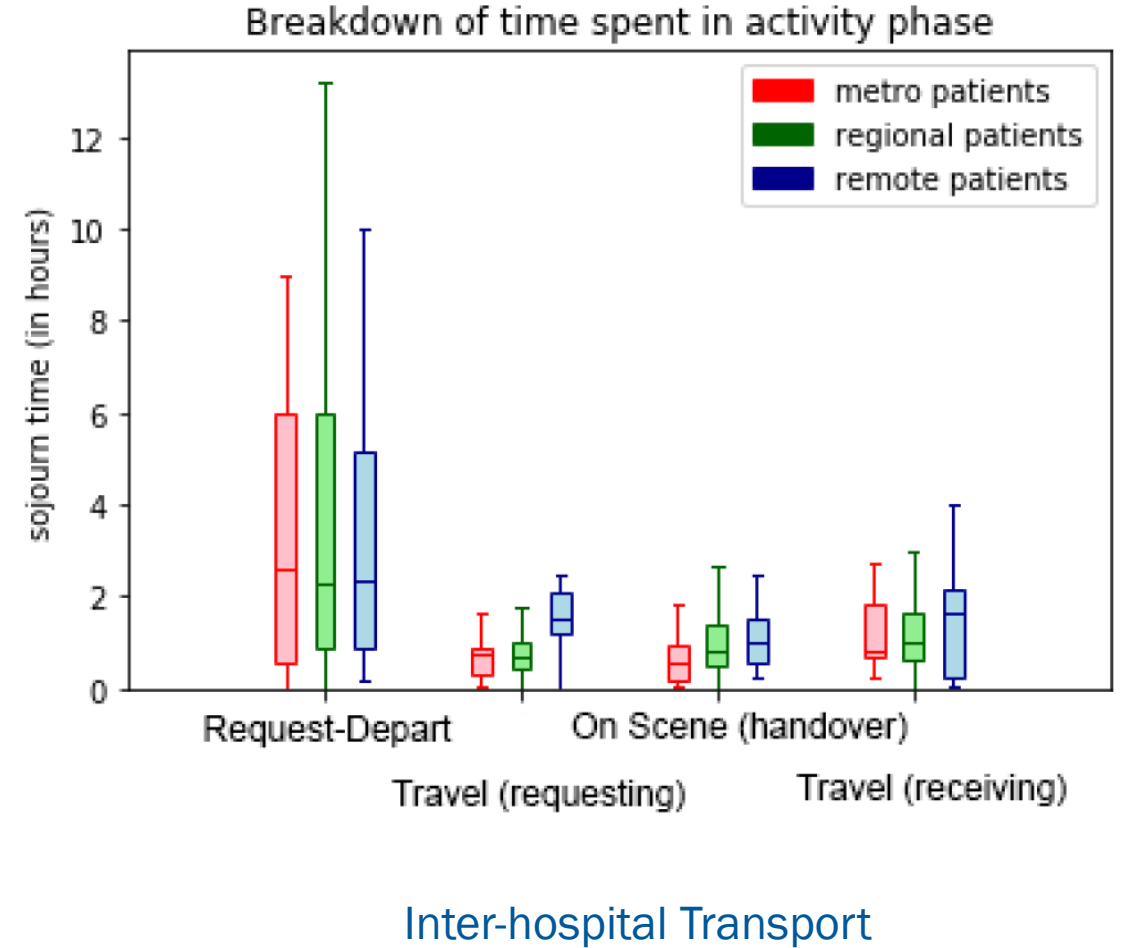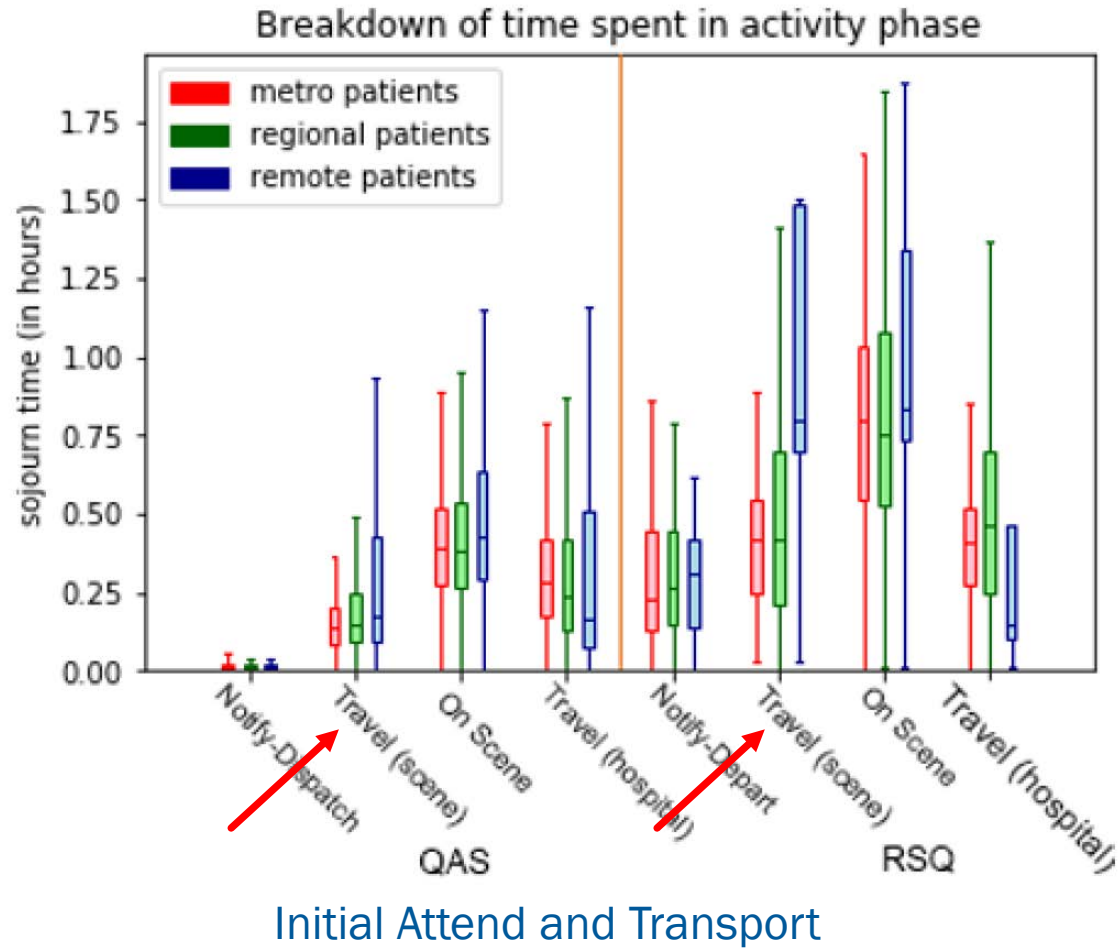
# MAJOR TRAUMA BY-PASS CONFORMANCE

- 65% conformance
  - 16% over-triage
  - 19% under-triage
  - Within acceptable limits
- Majority of over-triage where guideline recommended transport to other i.e, no RTS or MTS within 45mins
- 85% of cases met only a single qualifying criterion
  - Vital sign
  - Vehicle Rollover
- 50% of cases only required treatment at ED

Andrews, Robert, Wynn, Moe Thandar, Vallmuur, Kirsten, Elcock, Mark, Rashford, Stephen, Bosley, Emma, et al. (2021) Trauma by-pass guideline: A data-driven conformance analysis for road trauma cases in Queensland. EMA - Emergency Medicine Australasia.

- The table shows (i) the last recorded event, and (ii) LoS, for each patient in each cell that represents transport to a *lower* trauma service than recommended by the guidelines
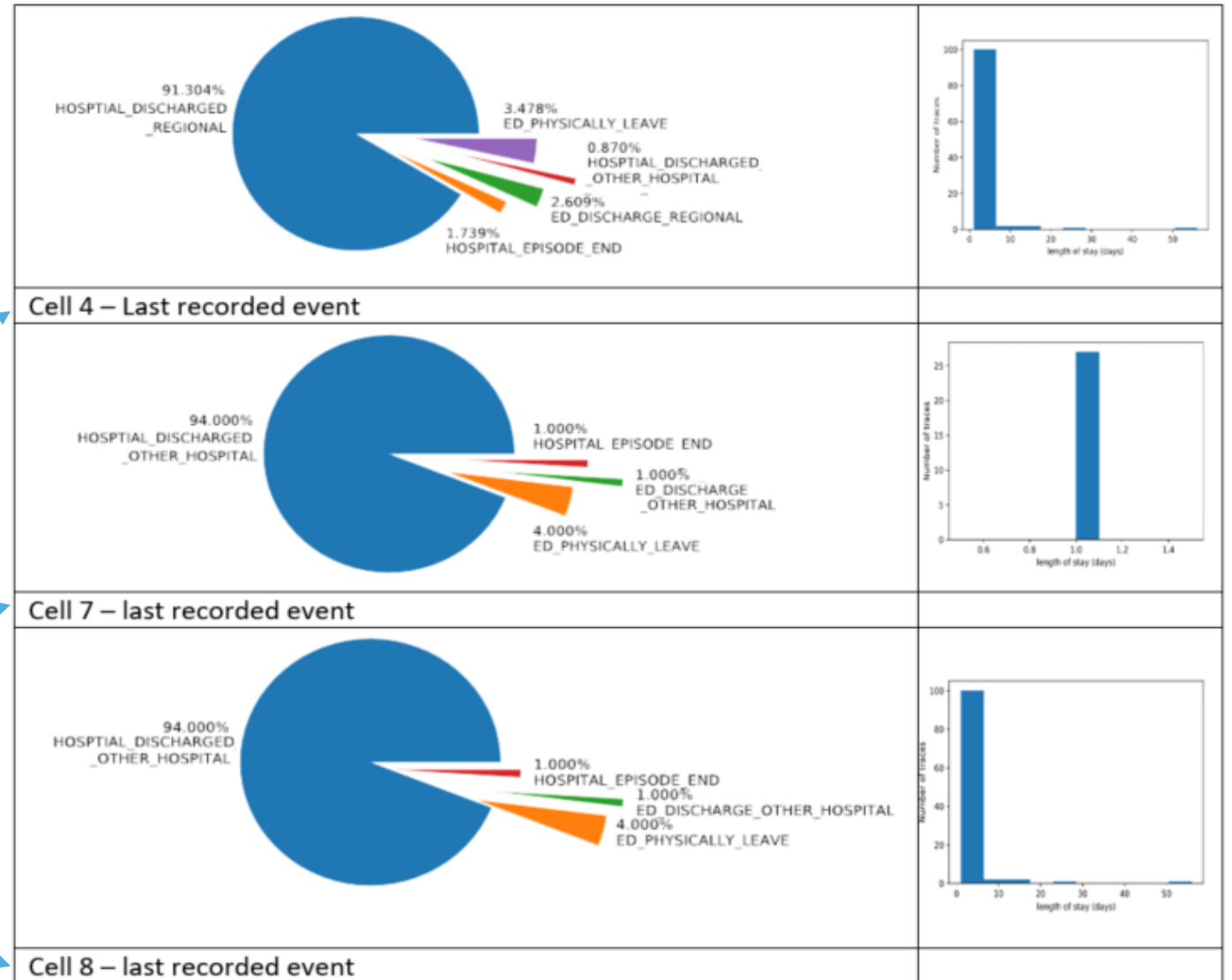
THANK YOU FOR LISTENING - ANY QUESTIONS?

Dr Robert Andrews

Business Process Management Group

School of Information Systems, Faculty of Science

Queensland University of Technology

r.andrews@qut.edu.au

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Andrews, Robert, van Dun, Chris, Wynn, Moe Thandar, Kratsch, Wolfgang, Roglinger, Max, & ter Hofstede, Arthur (2020) Quality-informed semi-automated event log generation for process mining. Decision Support Systems, 132, Article number: 113265.

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