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Process Mining to Identify Pathway Improvement Opportunities

Leeds Digital Health
6.15 pm 31st January 2024

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Healthcare in crisis
… are digital pathways the answer?

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NHS crisis sees 1MILLION extra patients turn to A&E departments in last year - with strikes, backlogs and difficulties accessing GPs blamed

- **There were 25m A&E attendances in England in 2022/23, up 4% from last year**
- **READ MORE: I'm a cancer patient who thinks it's a scandal that doctors can strike**

By SHAUN WOOLLER HEALTH EDITOR FOR THE DAILY MAIL
PUBLISHED: 17:45, 21 September 2023 | **UPDATED:** 20:55, 22 September 2023

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One million more patients attended A&E in the past year amid strikes, record waits for routine care and difficulties accessing a GP, figures show.

Health leaders say people have turned to emergency departments because it is one part of the **NHS** where they know the 'lights are on' and they will be seen.

But the surge in demand meant more patients waited longer than the target of four hours to be treated, admitted or discharged.

www.dailymail.co.uk/health/article-12545927/NHS-crisis-sees-1MILLION-extra-patients-turn-E-departments-year-strikes-backlogs-difficulties-accessing-GPs-blamed.html

NHS Digital › Services › Digital Services for Integrated Care › Digital Pathways Framework

Digital Pathways Framework

The Digital Pathways Framework will be the first framework to launch under the new Digital Services for integrated Care model.

Page contents

- Top of page
- The framework
- Information for buyers
- Information for suppliers
- Contact us

It is part of a new suite of frameworks designed to support modern general practice by providing standardised, assured, interoperable digital systems for primary care settings.

Solutions on the Digital Pathways Framework will be available to procure from the Buying Catalogue in early 2024.

It builds upon the Digital First Online Consultation Video Consultation (DFOCVC) Framework, which expires in March 2024.

The framework

The new Digital Pathways Framework will include new solutions to support patient pathways and assess patient needs. This includes initial online contact with a GP practice, navigation to the appropriate point of care, messaging and enabling patient interactions with the practice, and scheduling or booking appointments.

Products in the Digital Pathways Framework will cover these core Capabilities:

- online consultations and administrative request reporting
- online patient or service user consultation
- care navigation
- online administrative requests

In addition to at least one of the above, products may also provide:

- prescription ordering (for patients)
- communication management
- video consultation
- record viewing (for patients)
- cross organisational appointment booking

Information for buyers

The framework overview pack provides an overview of the framework and the digital tools that will enable modern general practice. One of the main commitments in the recovery plan.

It also shows the main actions for ICBs to prepare for the framework launching in early 2024. The information in this pack should be read in conjunction with the system letter and updated checklist of actions, published on 13 September.

https://digital.nhs.uk/services/digital-services-for-integrated-care/digital-pathways-framework

NHS Long Term Plan
Digital transformation

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Digital technology is a significant part of our everyday lives improving the way we socialise, shop and work. It also has great potential to improve how the NHS delivers its services in a new and modern way; providing faster, safer and more convenient care.

Our NHS Long Term Plan will increase the range of digital health tools and services. People will be able to seek health information and support online, and choose whether they speak to a doctor on the phone or in person. A wide range of NHS-approved apps will help people get ongoing support to help them manage their health and wellbeing needs, backed up by face-to-face care when this is needed.

We are also investing in improving NHS IT systems and in developing new technology. We will make sure staff have the technology they need to do their jobs, and our systems can talk to each other and share vital information to support the delivery of care.

Source: www.longtermplan.nhs.uk/areas-of-work/digital-transformation

The challenge
The NHS is a “Complex System”

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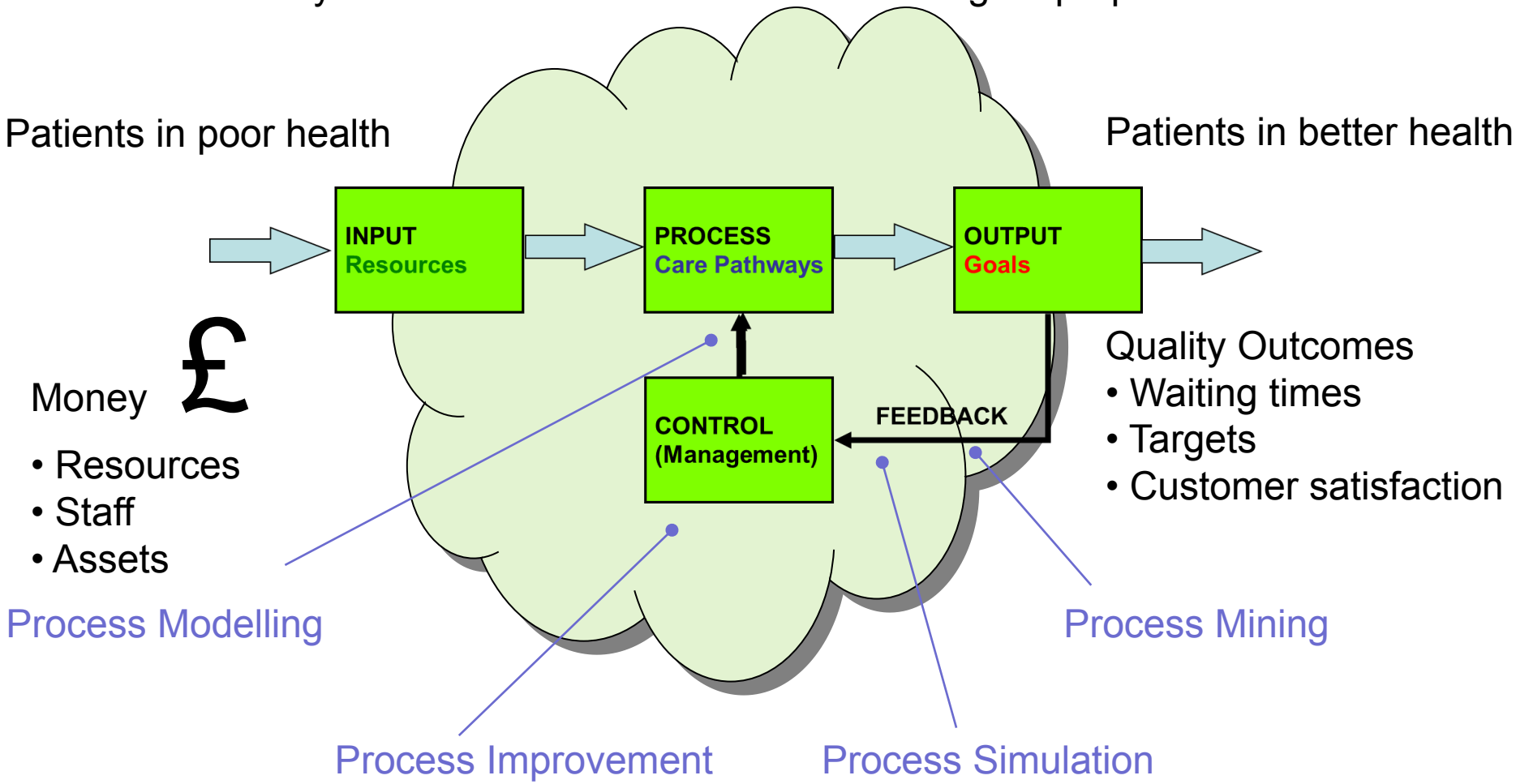
Health Organisations are **complex systems**
They have non-linear behaviour and emergent properties



Book chapter: Johnson, O., 2019. General System Theory and the Use of Process Mining to Improve Care Pathways. *Studies in health technology and informatics*, *263*, pp.11-22.

Designing new Digital Pathways

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Current → **Future**

Analysis of the "As is" pathway

Design of the "Will be" pathway

Pathway Improvement

Images: ChatGPT 4.0

Care Pathways
In design and in reality

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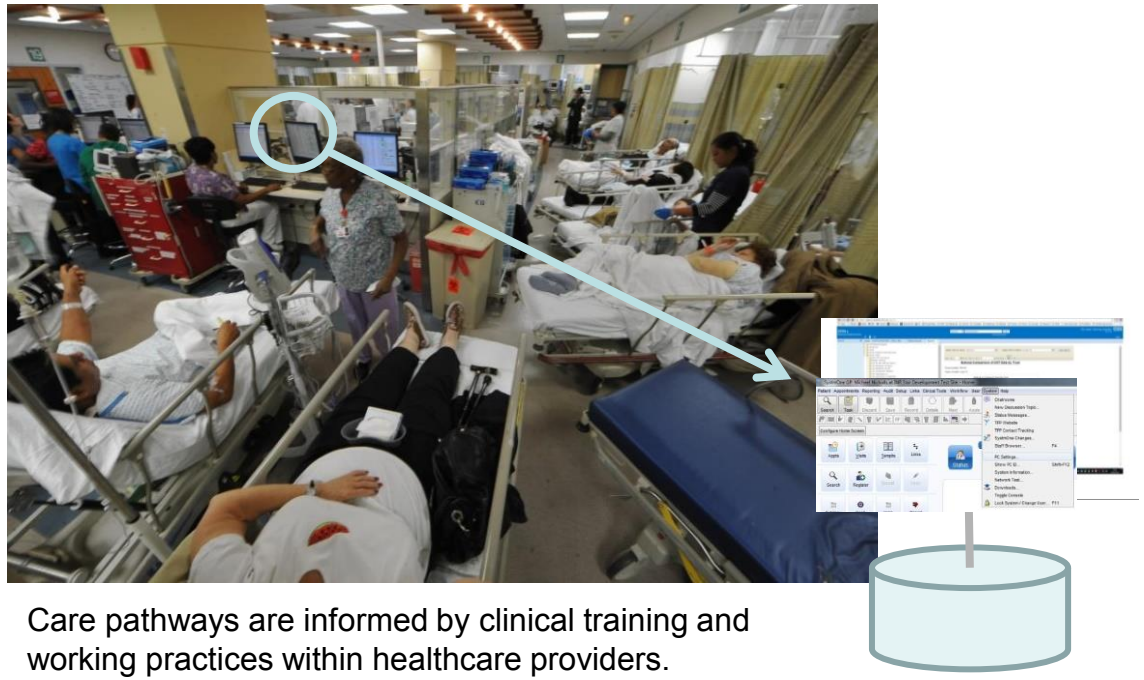
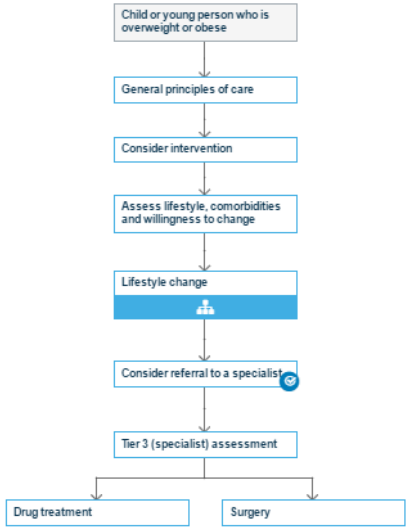
Typical
"As is" pathway



Care pathways are informed by clinical training and working practices within healthcare providers.
Care pathways are implemented, mediated and recorded by health information systems.

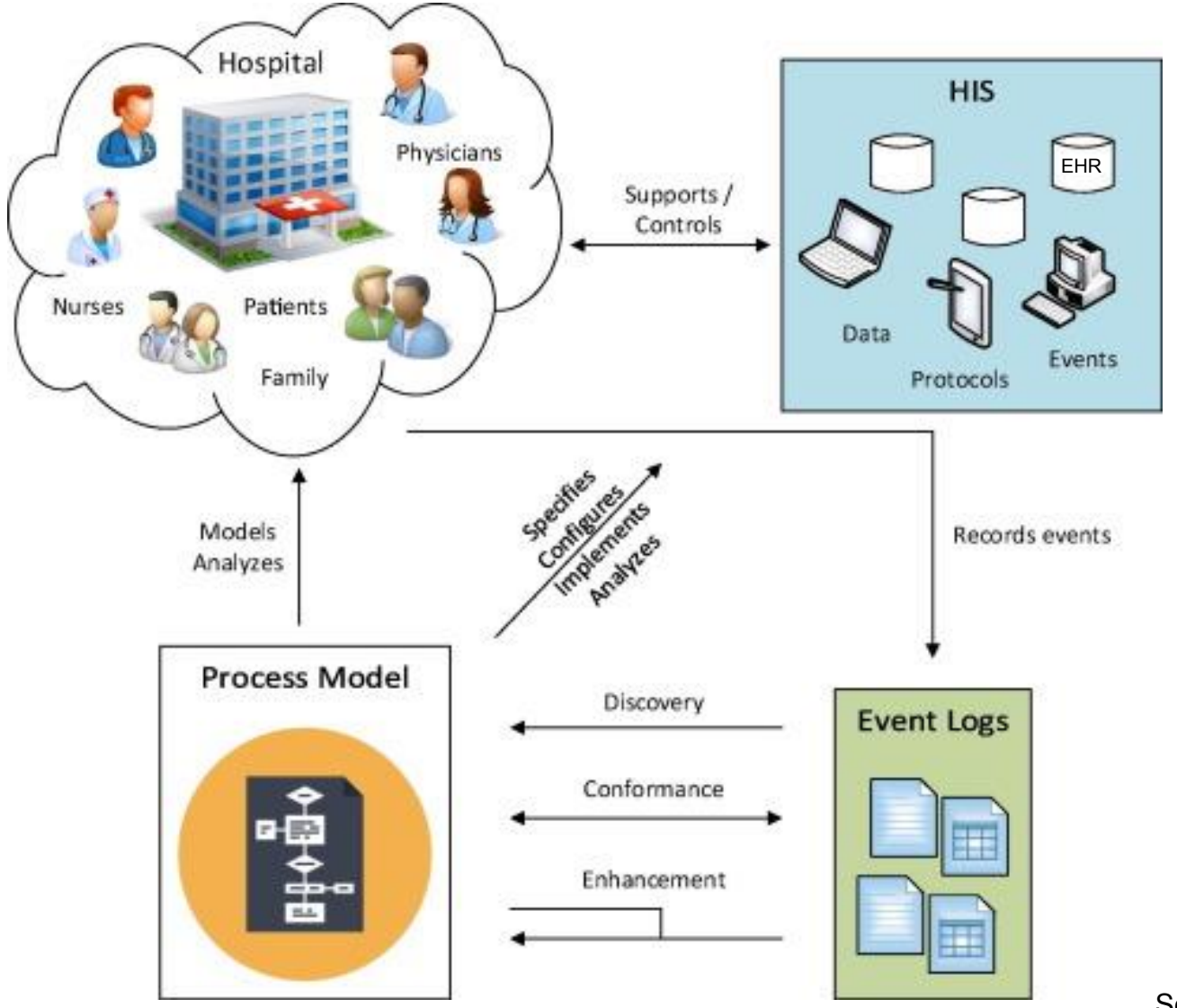
Typical
"Should be" pathway

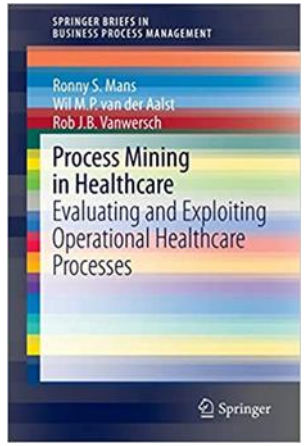


Example: Managing children and young people who are overweight or obese
pathways.nice.org.uk

NB NICE withdrew their comprehensive set of care pathway guidelines in 2022

Healthcare processes





Source: Manns et al (2015)

What is Process Mining?

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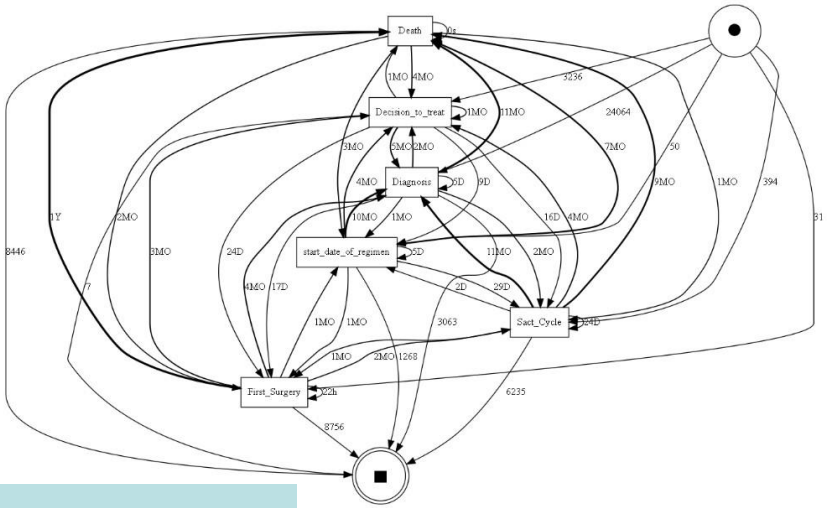
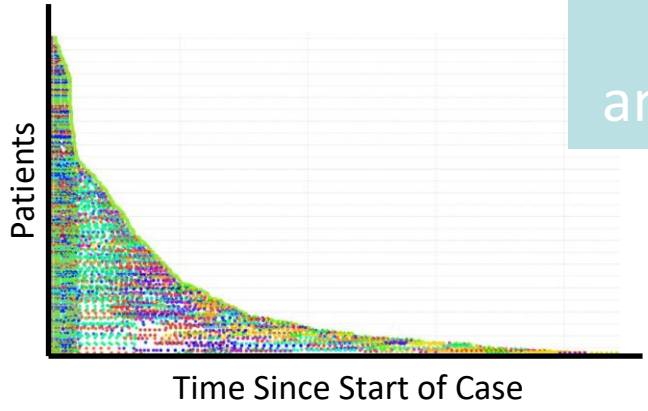
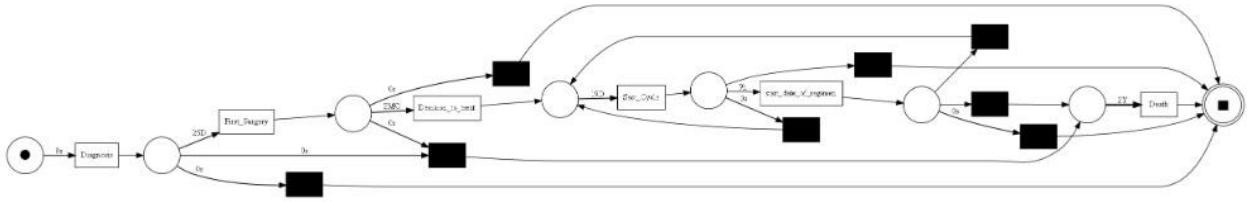
	Patient	Activity	Resource	Timestamp
0	patient 0	First consult	Dr. Anna	2017-01-02 11:40:11
1	patient 0	Blood test	Lab	2017-01-02 12:47:33
2	patient 0	Physical test	Nurse Jesse	2017-01-02 12:53:50
3	patient 0	Second consult	Dr. Anna	2017-01-02 16:21:06
4	patient 0	Surgery	Dr. Charlie	2017-01-05 13:23:09
5	patient 0	Final consult	Dr. Ben	2017-01-09 08:29:28





A tool to visualise and analyse business processes



Process Mining Research Field

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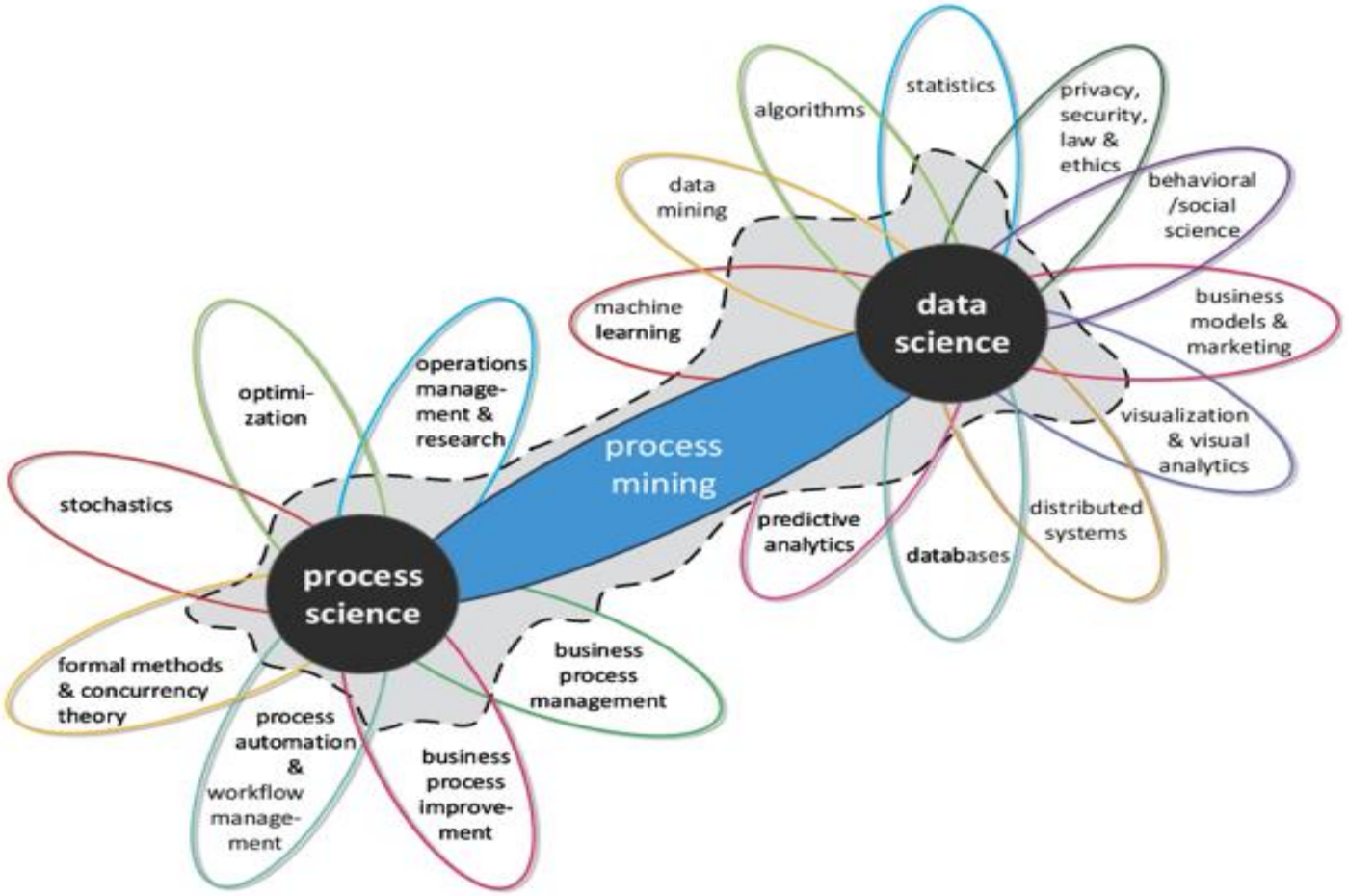

Process mining is bridging the gap between classical process model analysis and data science analysis. Process mining focuses on understanding real business processes using real data. In classical data mining people usually ignore the process.

The Process Mining for Healthcare Manifesto

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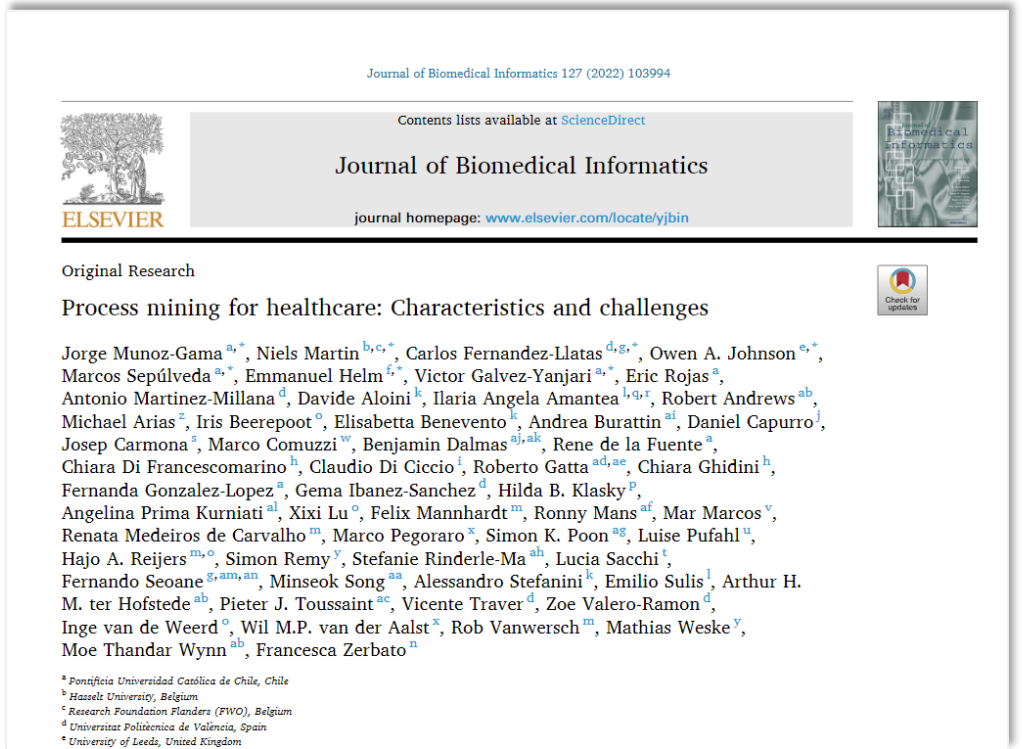
Based on a two-day brainstorming event in Hasselt, Belgium (July 2019)
Identified ten Characteristics of healthcare that make Process Mining in health different
And ten Challenges for future research…
.



Journal of Biomedical Informatics 127 (2022) 103994

Contents lists available at ScienceDirect

Journal of Biomedical Informatics

journal homepage: www.elsevier.com/locate/yjbin

Original Research

Process mining for healthcare: Characteristics and challenges

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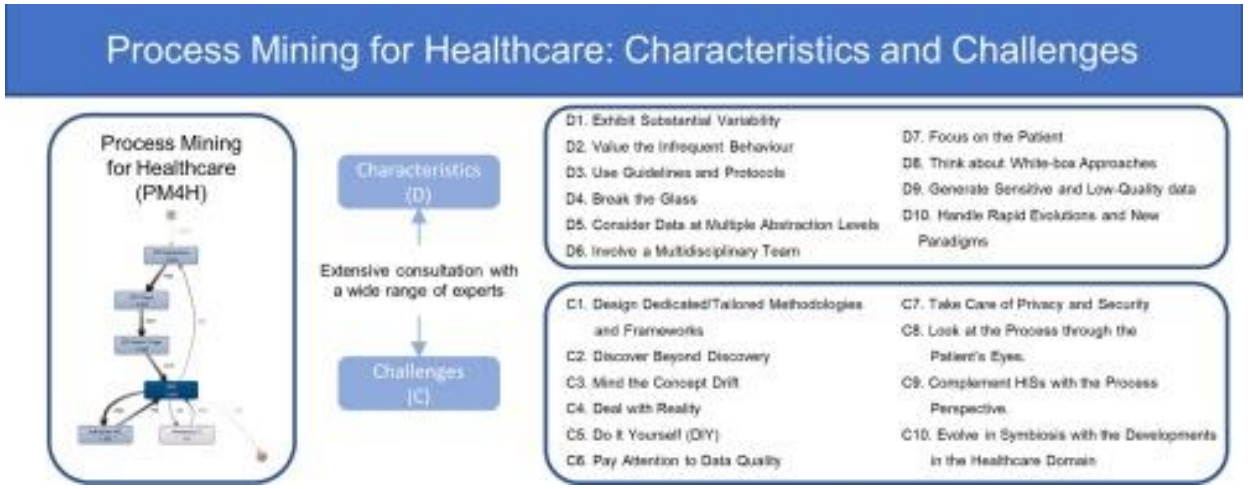
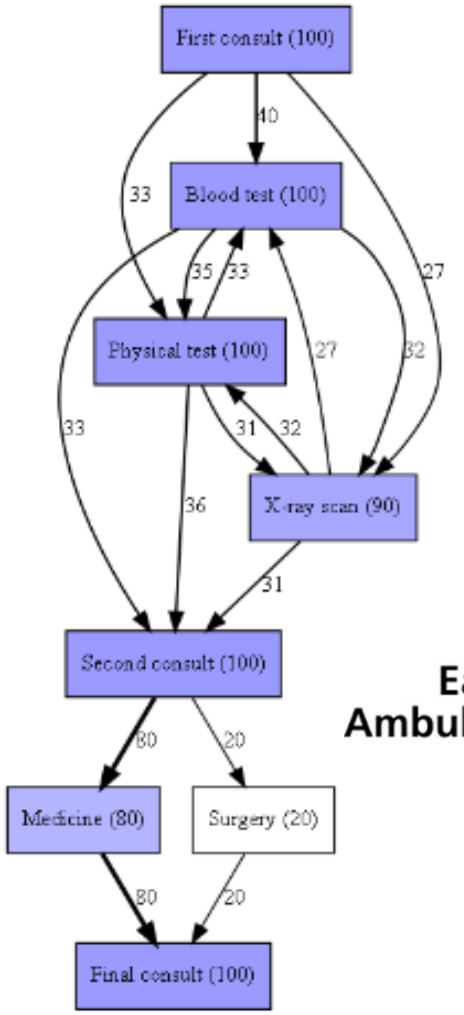


Munoz-Gama, J., Martin, N., Fernandez-Llatas, C., Johnson, O.A., Sepúlveda, M., Helm, E., Galvez-Yanjari, V., Rojas, E., Martinez-Millana, A., Aloini, D. and Amantea, I.A., 2022. Process mining for healthcare: Characteristics and challenges. *Journal of Biomedical Informatics*, p.103994

Process Mining to Generate Healthcare Pathways

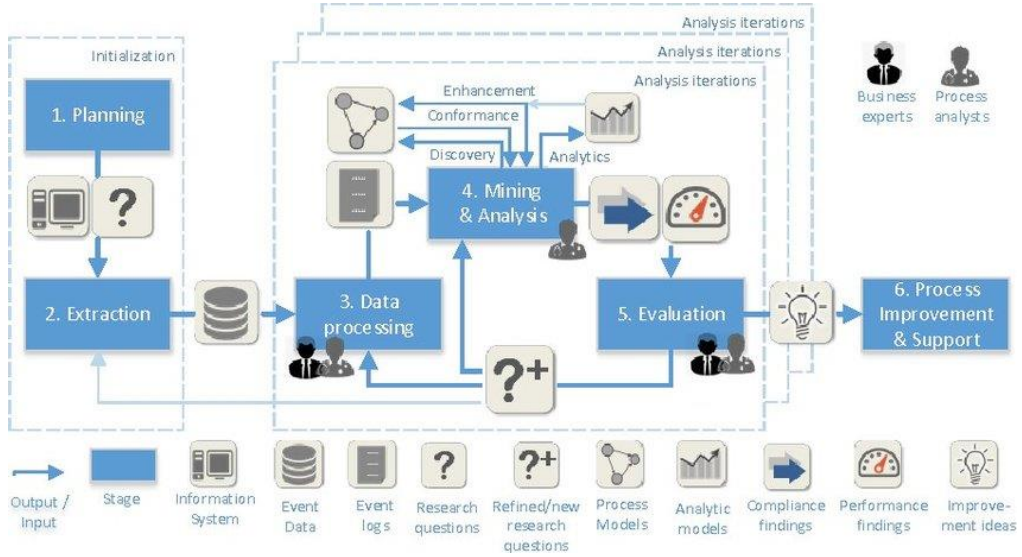
Alexander Coles



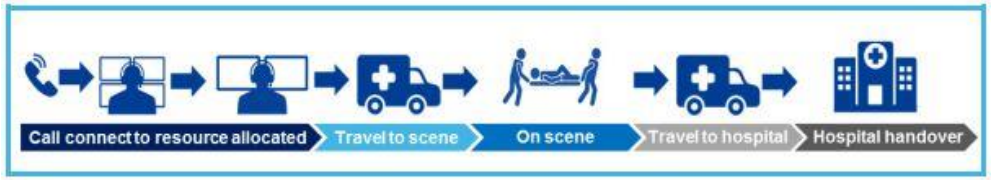
NHS England

NHS East Midlands Ambulance Service NHS Trust

EMAS Progress/Targets



PM2 Process Mining Methodology. Van Eck, M. L., Lu, X., Leemans, S. J. & Van Der Aalst, W. M. (2015), Pm: a process mining project methodology, in 'International conference on advance information systems engineering', Springer, pp. 297–313



Job Cyle from Public Services Committee (2023), 'Emergency healthcare: a national emergency.', https://committees.parliament.uk/publications/33569/documents/187215/default/[Accessed 25 September 2023

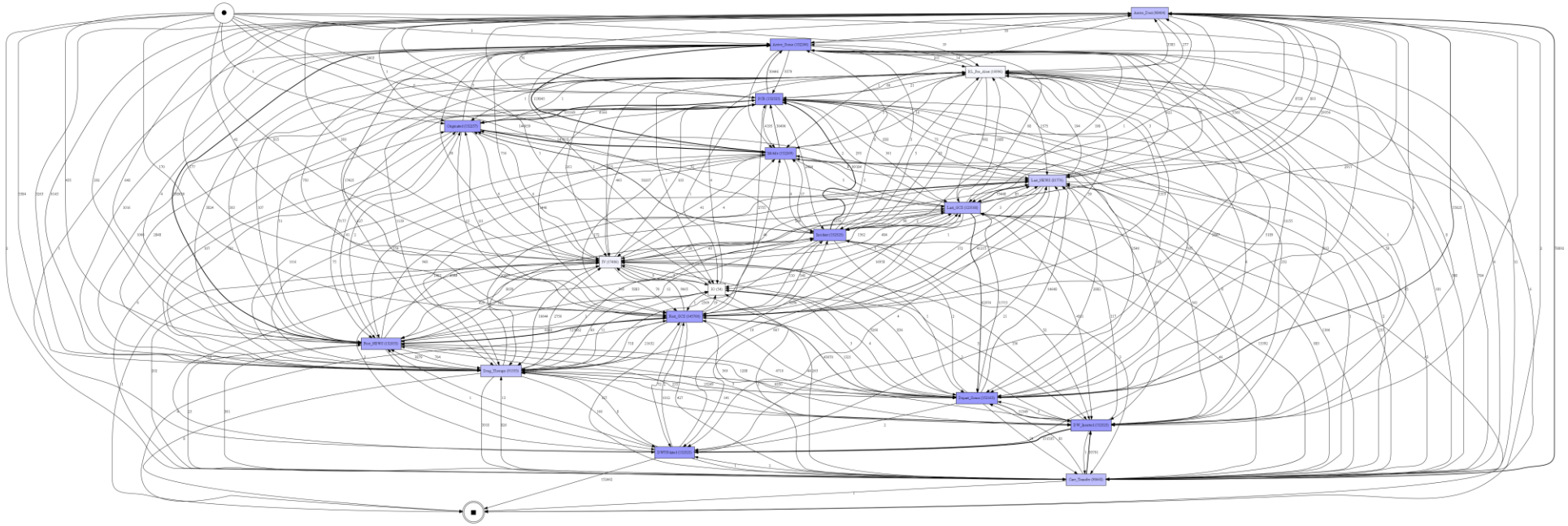
<u>Focus</u>

<u>Process Discovery</u>

- Category 2 makes up the majority of Ambulance Calls.
- Time to Scene, Time on Scene and Hospital Handover are of great interest to EMAS.
- How do attributes effect these job cycles (clinical category, Highest Qualification on scene, IMD etc)?

All Category 2

Every Trace Variant for Category 2 Data



Business Rules

- Some timestamps are not automatically recorded, allowing some human error in recording.

- We constructed business rules with our clinical experts to ensure that we focus on cases where key events are recorded in the expected chronological order

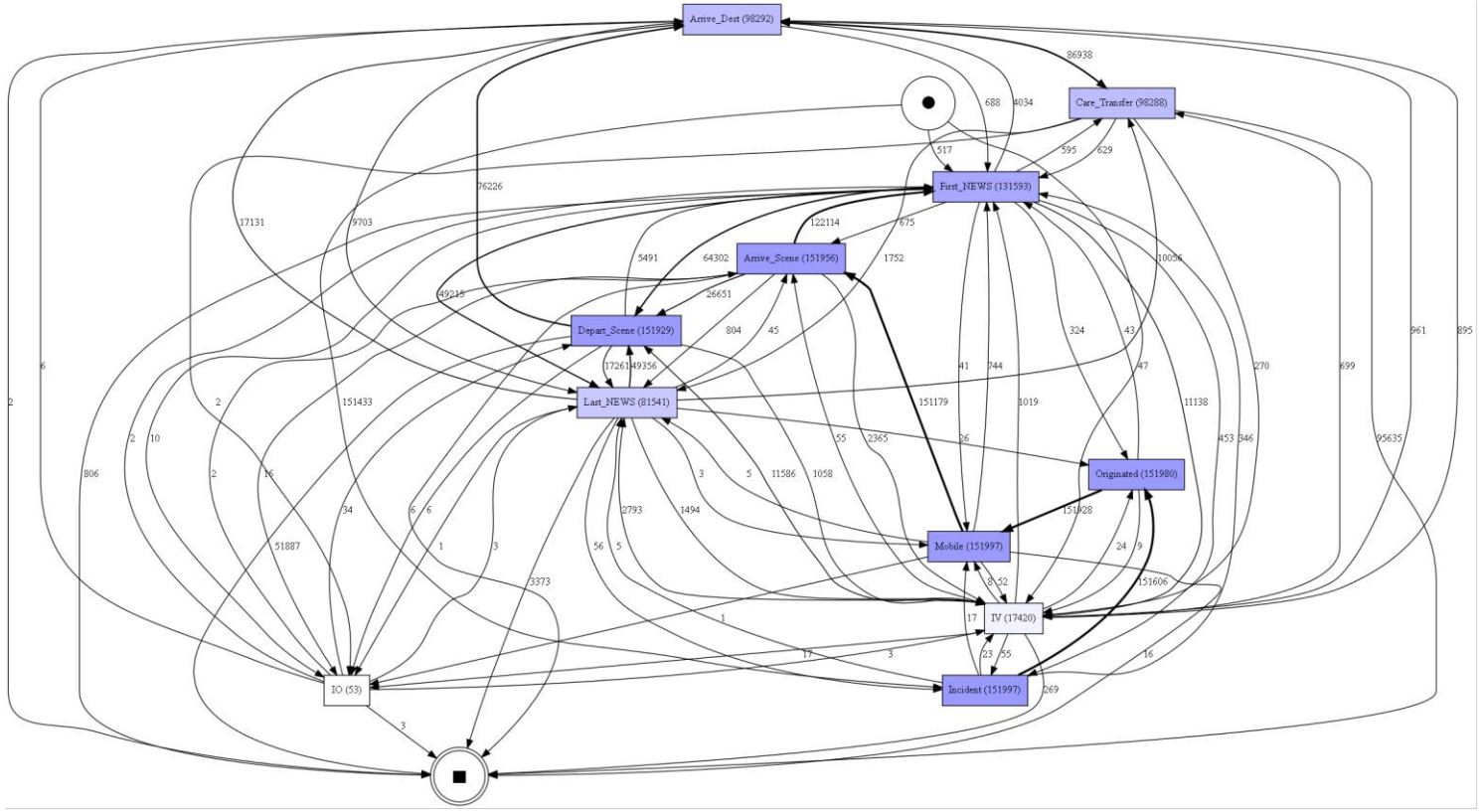
Business Rules – Remove Cases with Missingness

Filtered to Only Including Category 2 we originally had 152,525 patients:

Lost 528 Patients to Business Rules

Remaining Patients after removing patients that don’t follow rules 151,997

Business Rules Applied



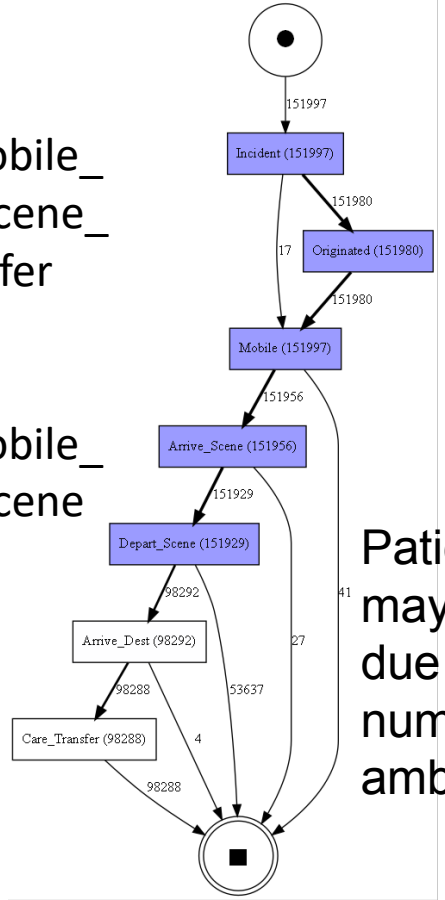
Filtered to Only Including Category 2 we originally had 152,525 patients:
Lost 528 Patients to Business Rules
Remaining Patients after removing patients that don’t follow rules 151,997

Remove “Optional” Events

8 Variants

~64% follow
Incident_Originated_Mobile_
Arrive_Scene_Depart_Scene_
Arrive_Dest_Care_Transfer

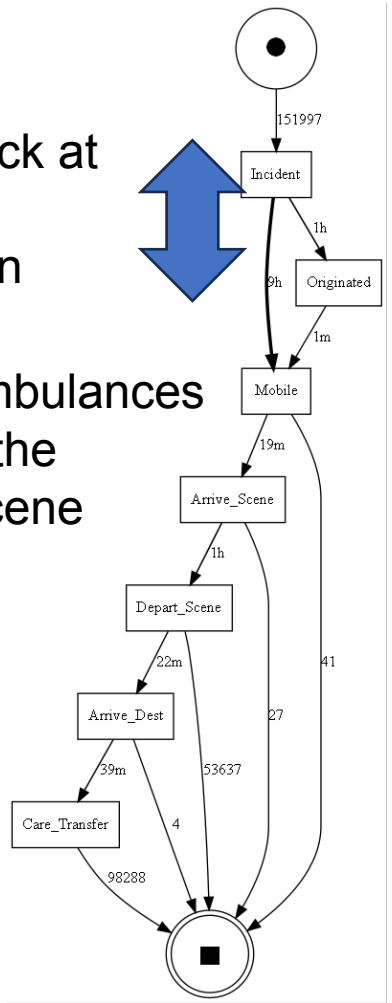
~35% follow
Incident_Originated_Mobile_
Arrive_Scene_Depart_Scene



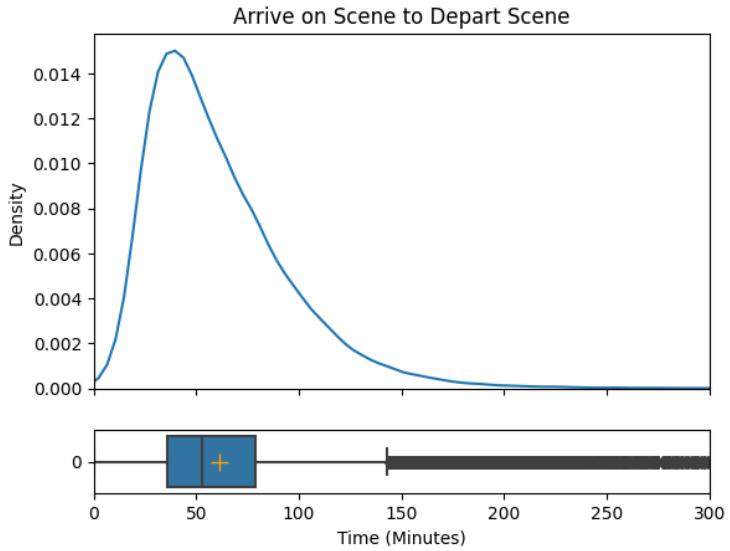
Patient handover maybe suffering due to increased number of ambulances

Bottleneck at crew allocation

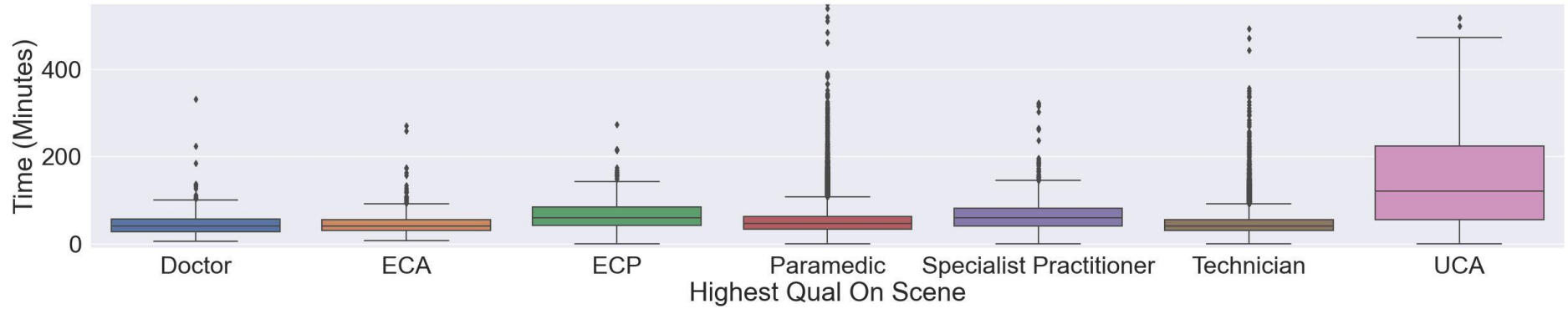
Available ambulances may not be the closest to scene



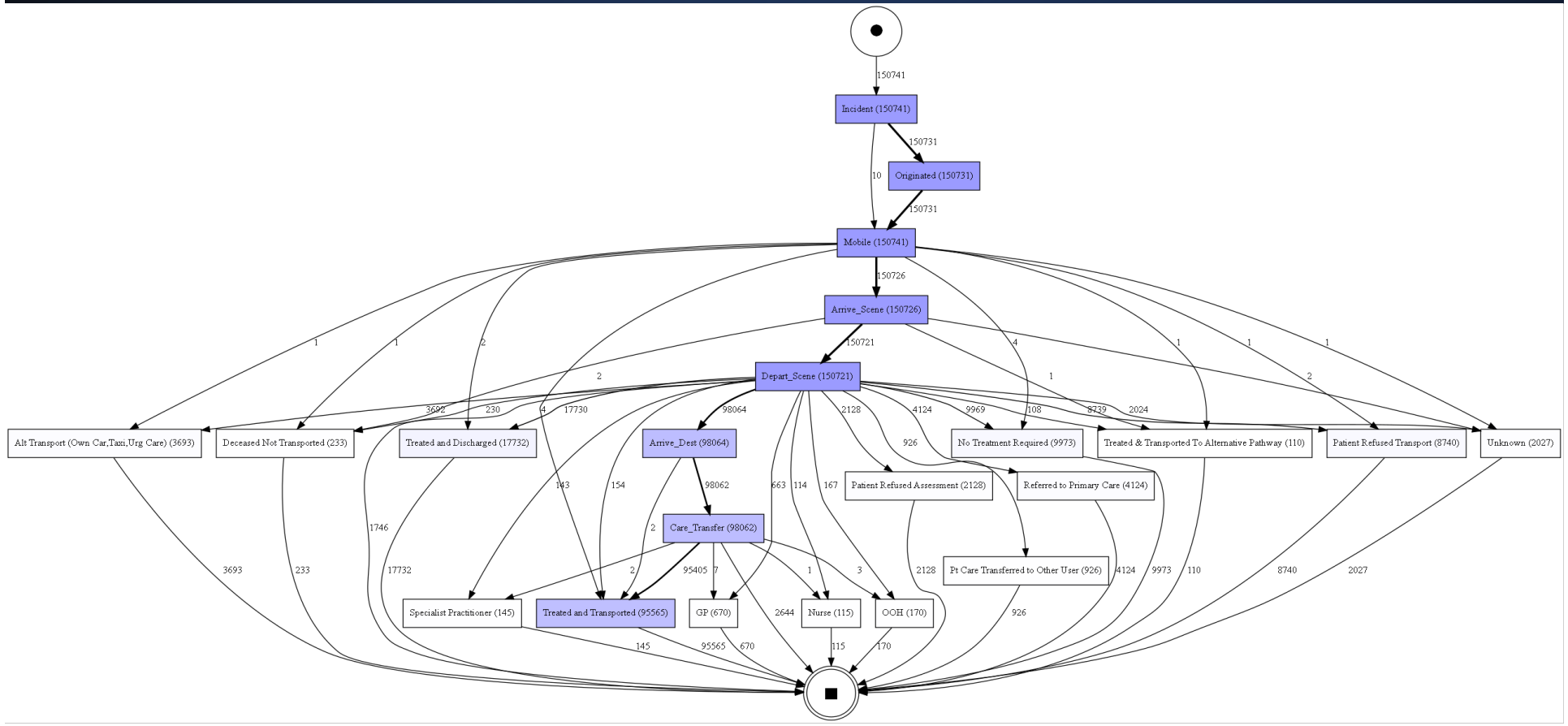
Analysis – Ambulance Arrive on Scene to Ambulance Depart Scene (Time on Scene)



Highest Qualification on Scene	Mean effect on mean time between Arrive_Scene and Depart_Scene (minutes)
UCA	97.898471
Specialist Practitioner	14.543051
ECP	13.385187
Paramedic	1.229887
Technician	-3.018392
ECA	-4.630408
Doctor	-10.980780

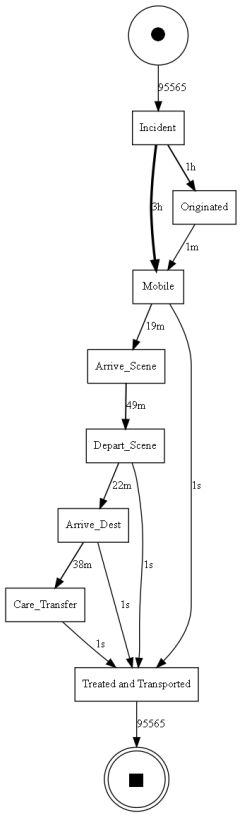


Add Outcome As Events

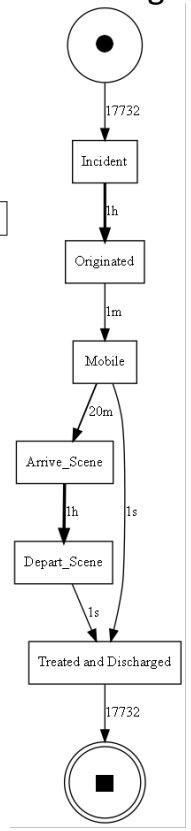


Filter by Outcome or by Category

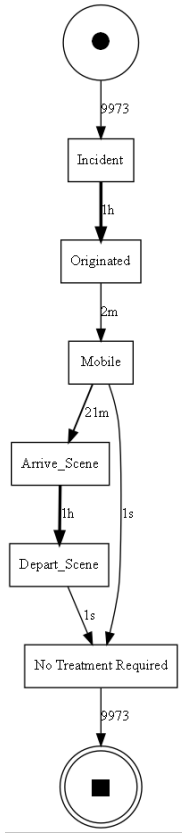
Treated & Transported



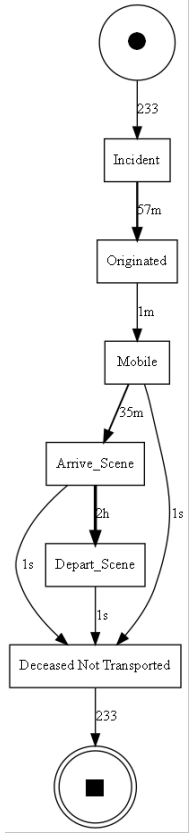
Treated & Discharged



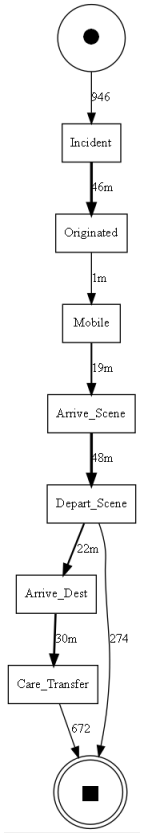
No Treatment Required



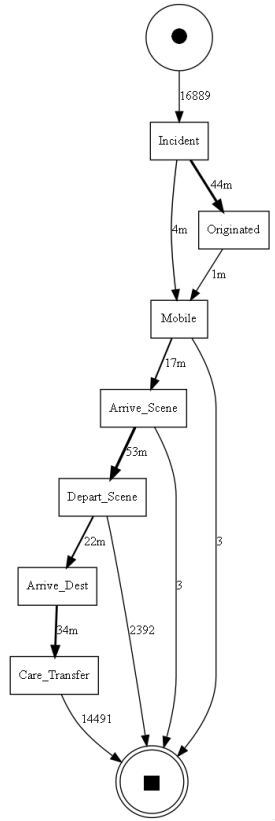
Deceased Not Transported



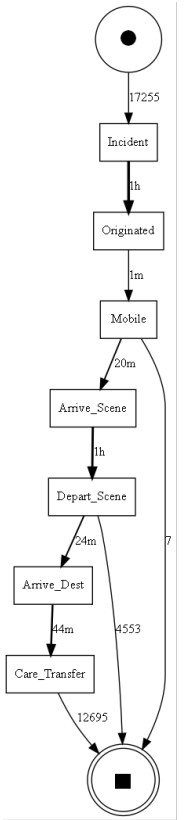
Obs/Gynae



Cardiovascular



Trauma

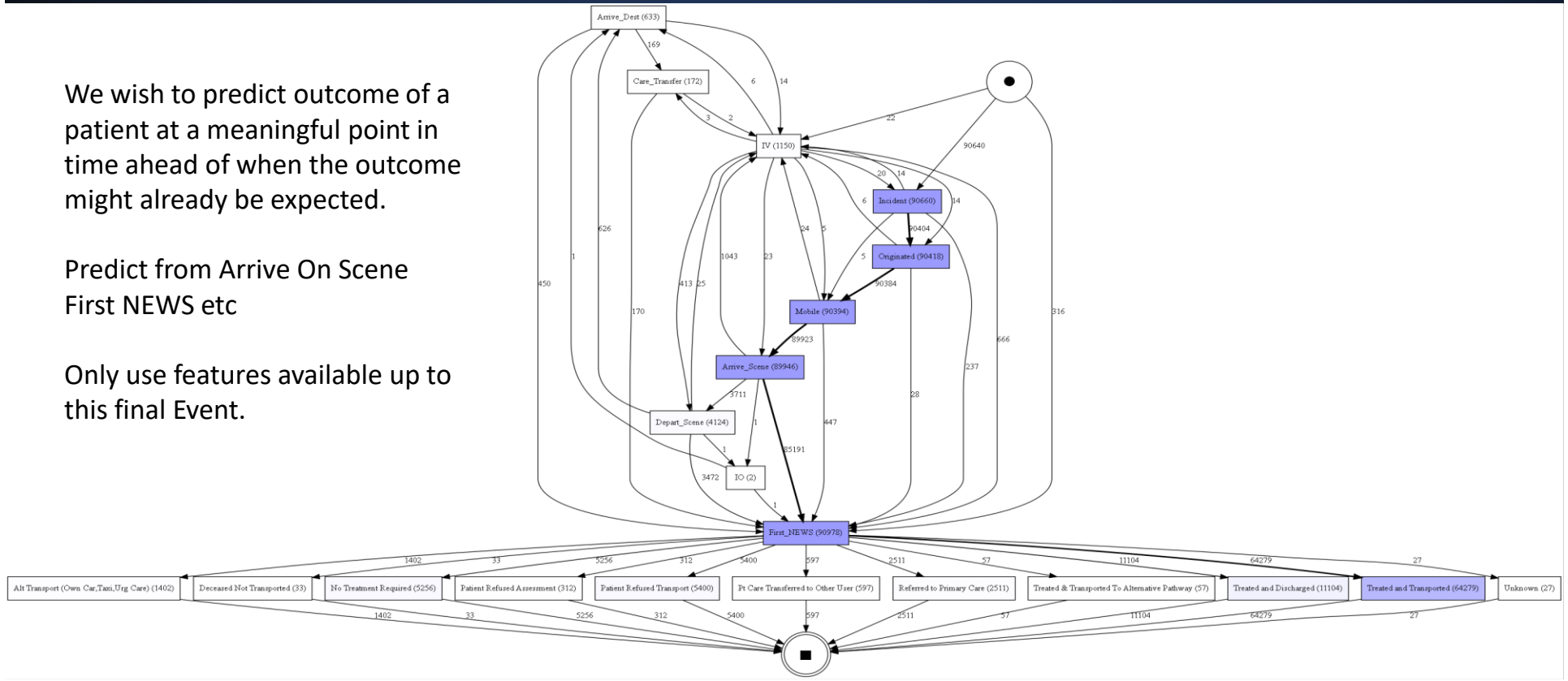


Applying Machine Learning to Predict Job Cycle Outcome

We wish to predict outcome of a patient at a meaningful point in time ahead of when the outcome might already be expected.

Predict from Arrive On Scene First NEWS etc

Only use features available up to this final Event.



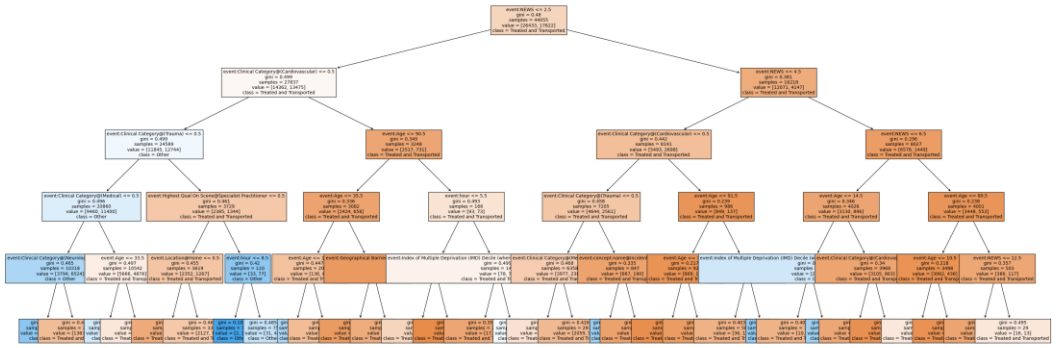
Modelling - Decision Tree to Predict Outcome

- Class imbalance with Treated and Transported
- Under sampled and grouped other classes into an umbrella class.

Leaf Colour by Class

100%
Other

100%
Treated and
Transported



Decision Tree
Feature Importances

Feature	Importance
Initial Clinical Category of Call	0.29
First Recorded National Early Warning Score (NEWS)	0.23
Age of Patient	0.17
Hour of Arrival on Scene	0.10
Index of Multiple Deprivation (IMD) Decile at Incident Location	0.075
Day of the Week	0.065
Highest Qualification on Scene	0.038

Findings & Resources

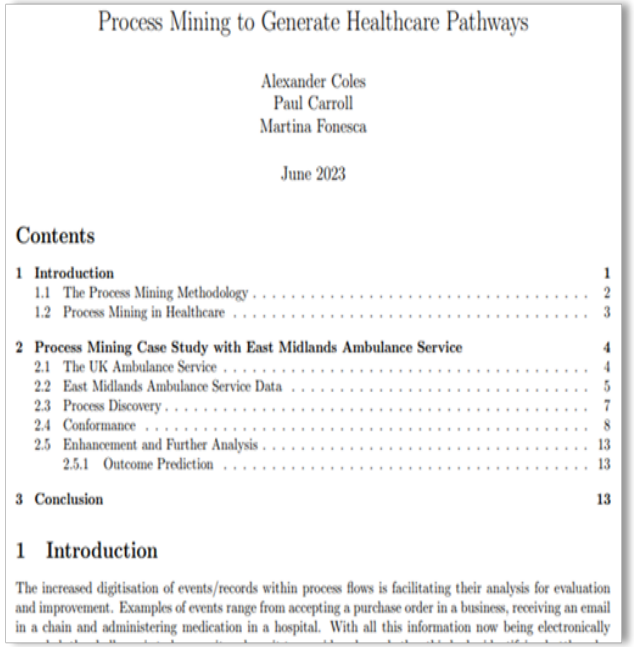
- Observed bottlenecks at crew allocation and handover.
- Measured the effect of different attributes on the response time, time spent on scene and handover time
- Tried to predict whether a patient was to transported to hospital. More data required to do this accurately.

Resources

PM4PY: https://pm4py.fit.fraunhofer.de
BUPAR: https://bupar.net,
Celonis: https://www.celonis.com
Disco: https://fluxicon.com/disco,
Prom: https://promtools.org

Project Report and Code available on NHS England's GitHub

https://github.com/nhsengland/ProcessMining



Process Mining to Generate Healthcare Pathways

Alexander Coles
Paul Carroll
Martina Fonesca

June 2023

Contents

1 Introduction

The increased digitisation of events/records within process flows is facilitating their analysis for evaluation and improvement. Examples of events range from accepting a purchase order in a business, receiving an email in a chain and administering medication in a hospital. With all this information now being electronically

Care Pathways in the NHS follow typical patterns

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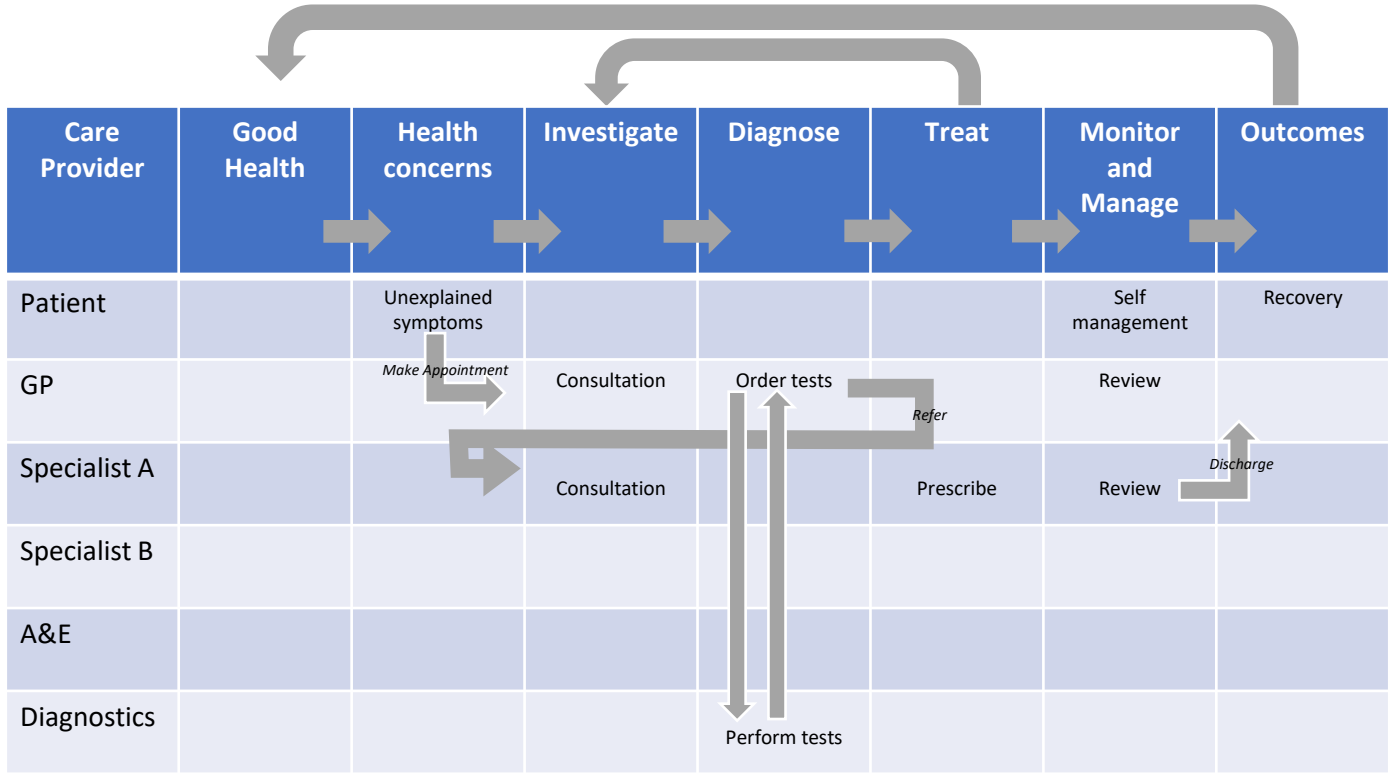
Most care pathways will follow one or more standard template patterns
Linear, Cycle, Referral, Sub-process, Parallel process
Opportunity to share and transfer learning within the Digital Health and NHS community.



Designing new Digital Pathways

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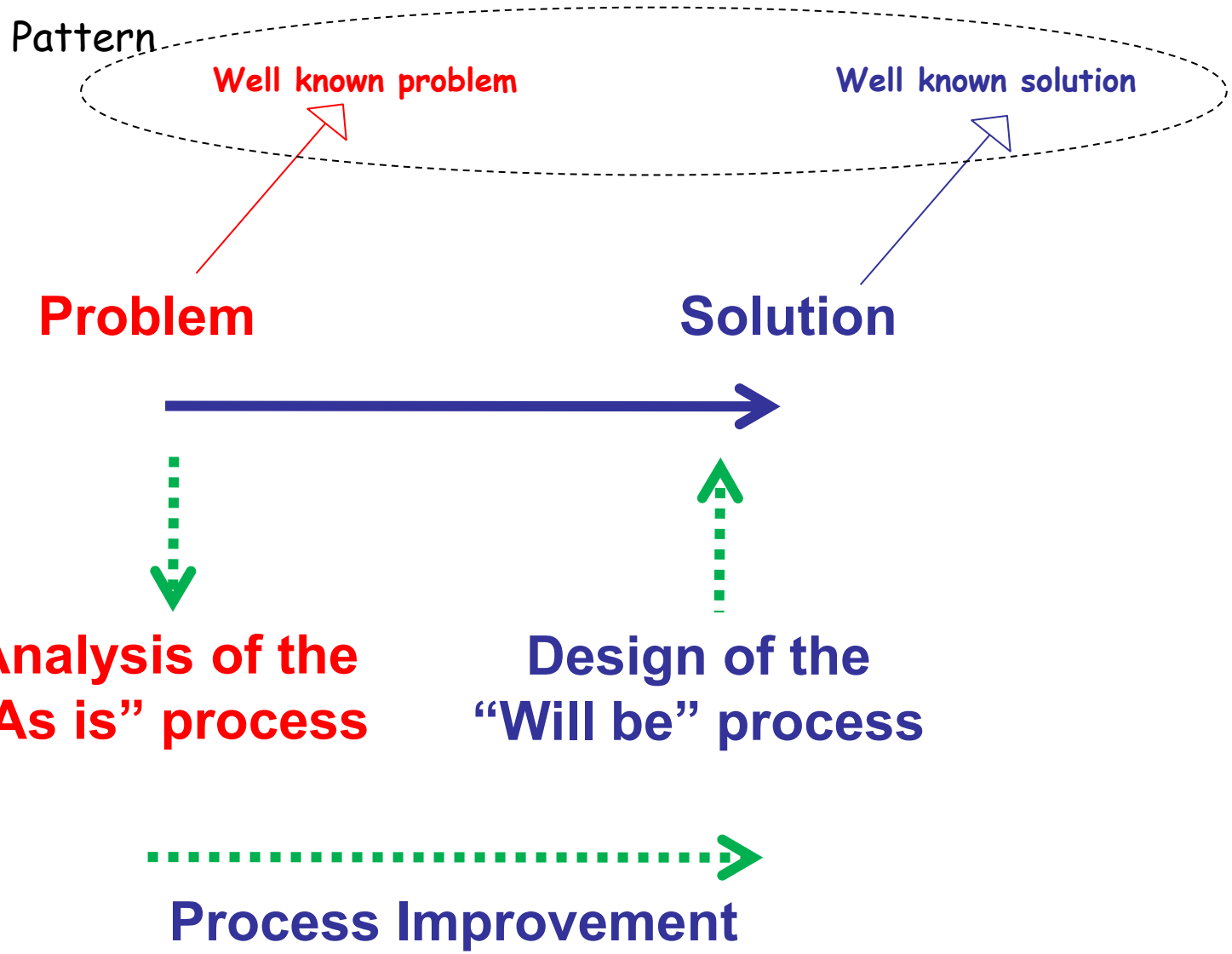

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Process Mining to Identify Pathway Improvement Opportunities

Leeds Digital Health
6pm 31st January 2024

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