Digital transformation is everywhere, but are we making life safer for patients?

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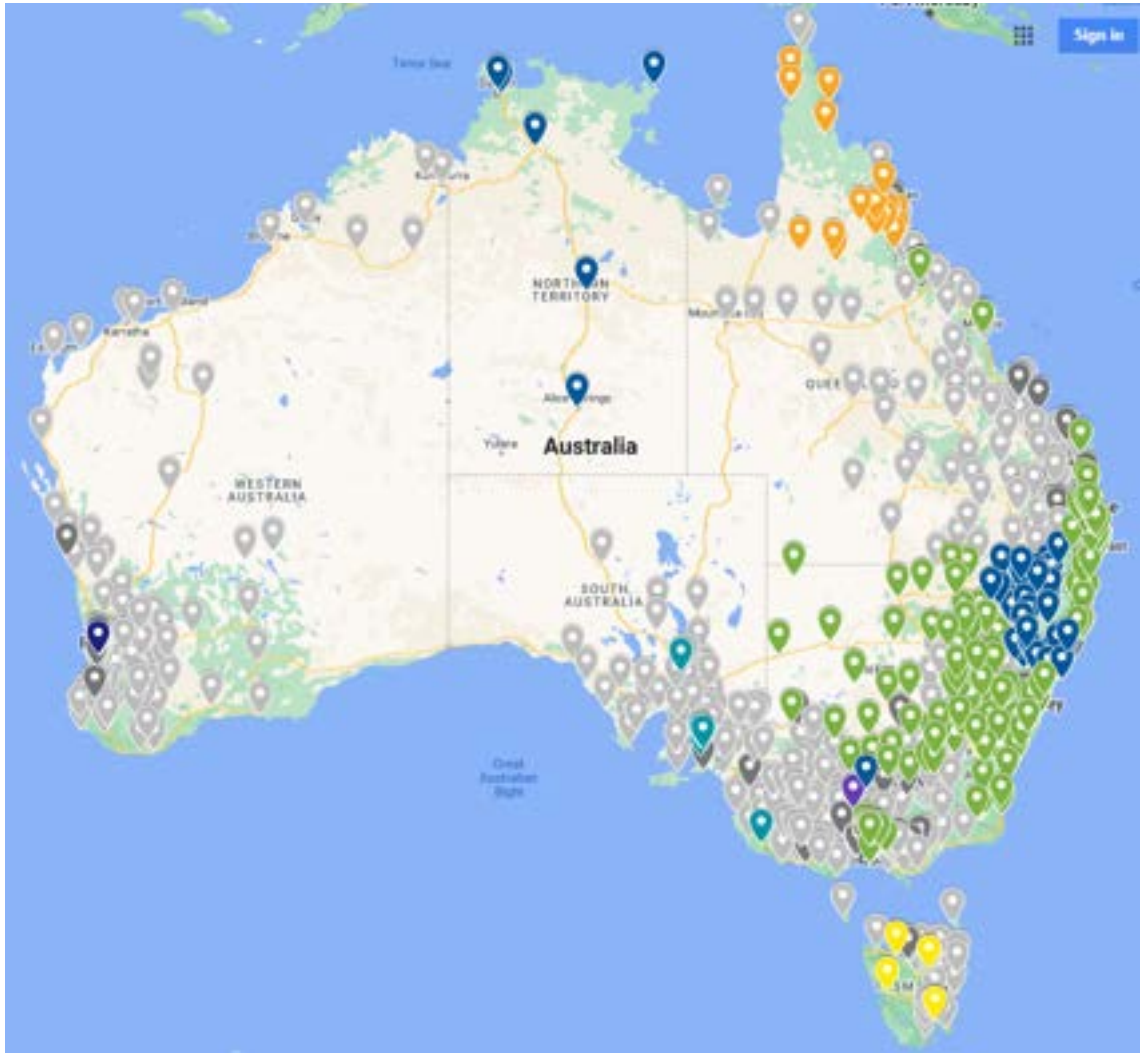
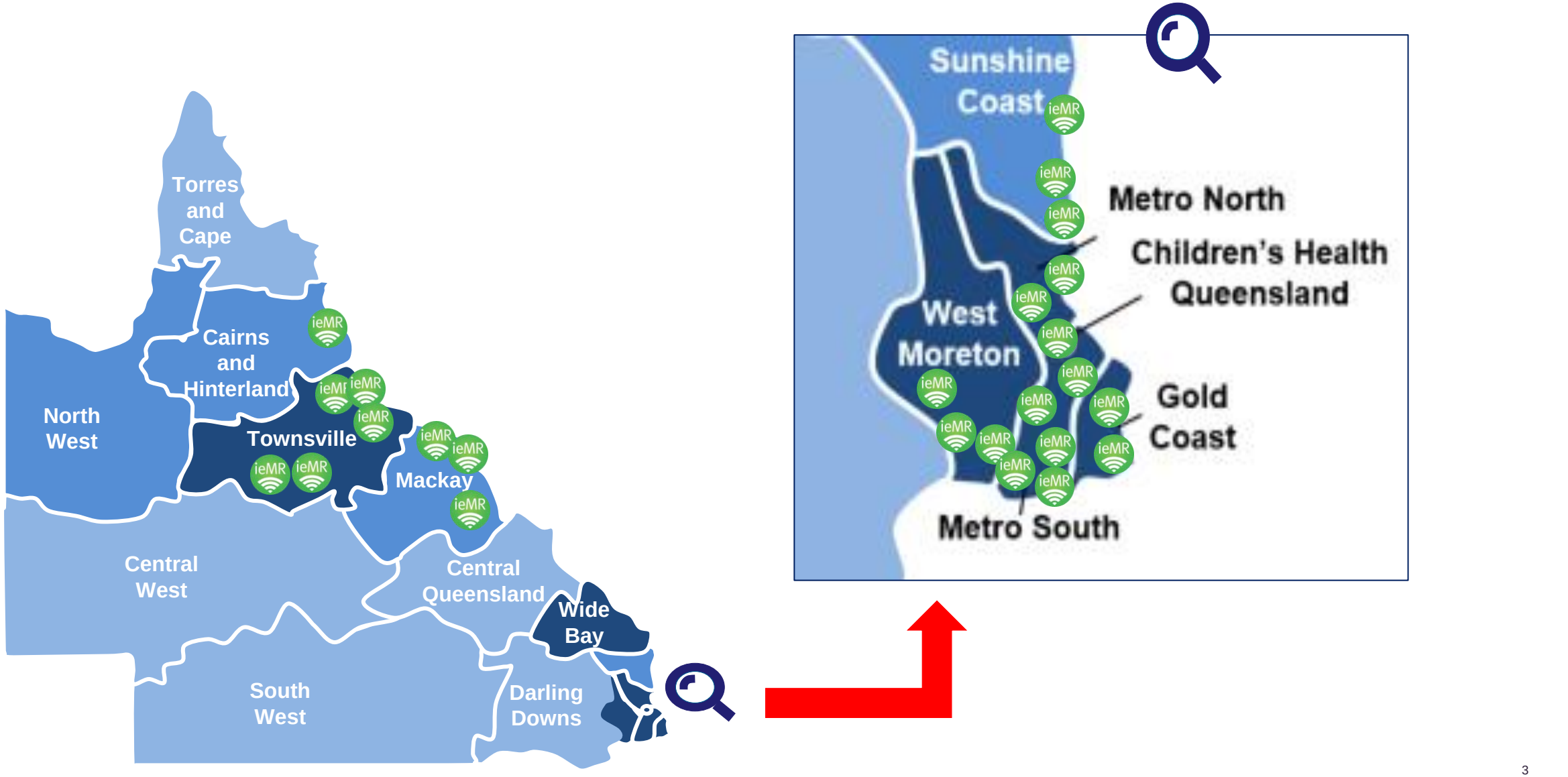
Australia's Healthcare Digital Transformation Journey

- **Both public and private healthcare sectors**
- **Universal health insurance, covers:**
  - Hospital treatments
  - General Practice consultations
  - Medication subsidies
  - Other services
- **State governments operate public hospitals**
- **Hospitals and primary care are at different stages of EMR adoption (scale and maturity)**



Ref: bit.ly/dhospmap

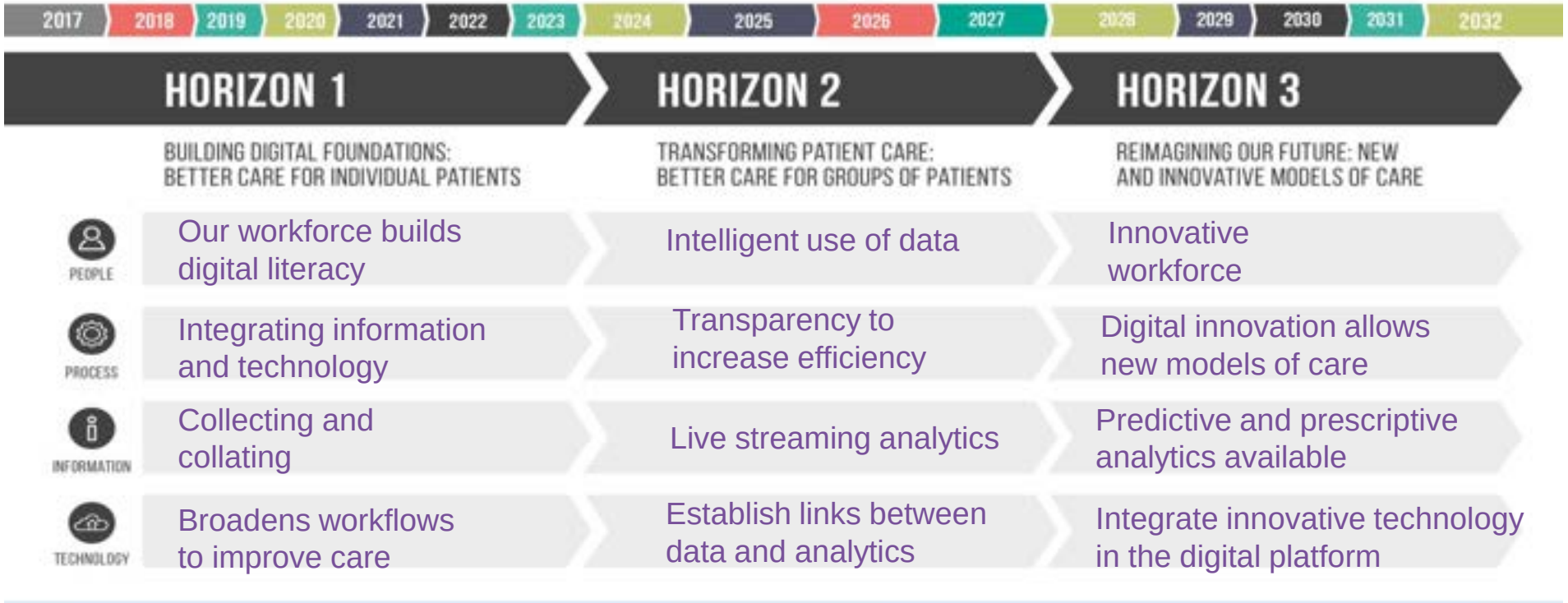
Queensland Health's ieMR roll-out



Queensland Health's ieMR Usage Statistics (Jul 2024)

- 32,716 users log into the ieMR system each business day
- Average of 4.9 million electronic orders each month
- Sign more than 333,956 clinical notes per month
- Information is stored in 8,682 back-end data tables (e.g. clinical event table > 8,520 million rows)
- Huge storage capacity - database currently sits at 74.8 terabytes + 138 terabytes for scanned documentation

Horizons of digital health



Learning Health System

All data entered during an episode of care is used to improve the care of subsequent consumers.

My Research….

Medication Safety in Hospitalised Inpatients

- Medication incidents – higher incidence of errors/adverse events than any other healthcare intervention
- Australian National Safety and Quality Healthcare Standard – Medication Safety (Std 4)
- Medication Management Pathway
- High risk medications
- Electronic medication management systems (eMMS)

Why Anticoagulants?

- ‘Blood-thinning’ drugs
- Used extensively in clinical practice
- High risk medications
- Can cause significant patient harm/death if used inappropriately
- Commonly implicated in adverse events in hospitalised patients
- Therapeutic use requires tight dose control

Digitising Anticoagulation Therapy

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Review article

Interventions designed to improve the safety and quality of therapeutic anticoagulation in an inpatient electronic medical record

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PRELIMINARY WORK:

Systematic Review

Case Report

Article published online: 2021-11-15

e116 Case Report

Safe and Effective Digital Anticoagulation: A Continuous Iterative Improvement Approach

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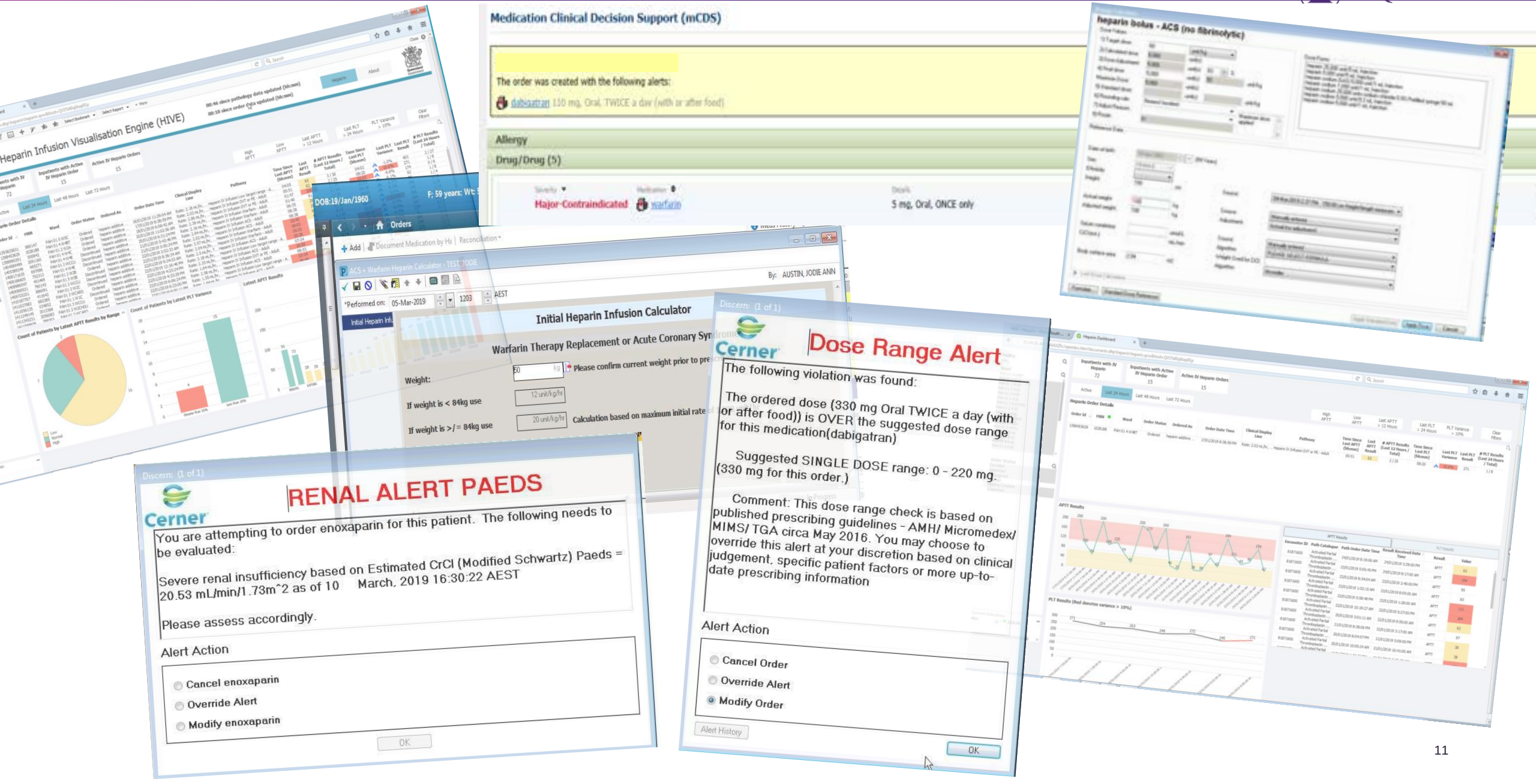
ACI Open 2021;5:e116–e124.


Heparin Infusion Visualisation Engine (HIVE)
Medication Clinical Decision Support (mCDS)
The order was created with the following alerts:
dabigatran 110 mg, Oral, TWICE a day (with or after food)
Allergy
Drug/Drug (5)
Major-Contraindicated
warfarin
5 mg, Oral, ONCE only
heparin bolus - ACS (no fibrinolytic)
Orders
Initial Heparin Infusion Calculator
Warfarin Therapy Replacement or Acute Coronary Syndrome
Weight:
If weight is < 84kg use
If weight is >/= 84kg use
Calculation based on maximum initial rate
Discern: (1 of 1)
Cerner
RENAL ALERT PAEDS
You are attempting to order enoxaparin for this patient. The following needs to be evaluated:
Severe renal insufficiency based on Estimated CrCl (Modified Schwartz) Paeds = 20.53 mL/min/1.73m^2 as of 10 March, 2019 16:30:22 AEST
Please assess accordingly.
Alert Action
Cancel enoxaparin
Override Alert
Modify enoxaparin
OK
Discern: (1 of 1)
Cerner
Dose Range Alert
The following violation was found:
The ordered dose (330 mg Oral TWICE a day (with or after food)) is OVER the suggested dose range for this medication(dabigatran)
Suggested SINGLE DOSE range: 0 - 220 mg. (330 mg for this order.)
Comment: This dose range check is based on published prescribing guidelines - AMH/ Micromedex/ MIMS/ TGA circa May 2016. You may choose to override this alert at your discretion based on clinical judgement, specific patient factors or more up-to-date prescribing information
Alert Action
Cancel Order
Override Alert
Modify Order
Alert History
OK

Digitising Anticoagulation Therapy

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Research Question

“What is the impact of ieMR implementation on the quality and safety of therapeutic anticoagulation management and what are the potential targets for intervention for ieMR optimisation?”

Retrospective, observational study across 5 hospital sites from a single HHS

- **1038-bed metropolitan hospital offering quaternary level care**
- **485-bed hospital offering mix of secondary and tertiary level care**
- **175-bed metropolitan hospital**
- **172-bed metropolitan hospital**
- **28-bed rural health care hospital**

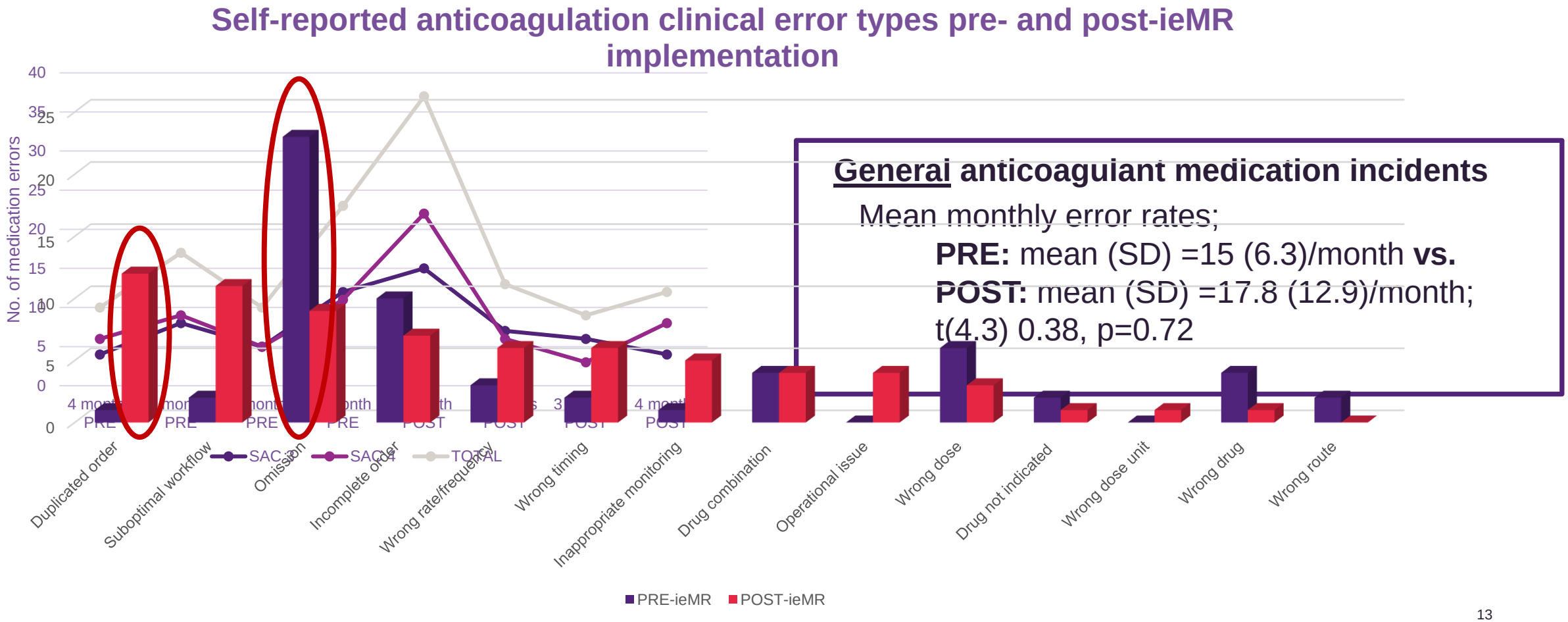
Hospitalised inpatients on therapeutic anticoagulation 1 year pre- and 1 year post-ieMR implementation

Four metrics:

- **Clinician-reported medication incidents**
- **Toxic pathology results**
- **Clinical outcomes – bleeds associated with anticoagulant use**
- **Heparin-induced thrombocytopenia**

Clinician-reported medication errors

- **RISKMAN data**



General anticoaguiant medication incidents

Mean monthly error rates;

PRE: mean (SD) =15 (6.3)/month **vs.**

POST: mean (SD) =17.8 (12.9)/month;

t(4.3) 0.38, p=0.72

Toxic pathology results

The University Of Queensland AUSTRALIA

AUSLAB pathology system interfaces with QH ieMR

Surrogate markers for toxicity of UFH (aPTT > 110 secs and >200 secs), warfarin (INR > 3.5 and >5.5) or LMWH (anti-factor Xa > 1.0 IU/mL)

Percentage of total reported results for each pathology test

Exclusion criteria: aPTT < 50 seconds, INR < 1.5 and anti-factor Xa <0.4 IU/mL

Toxic pathology result	PRE-ieMR implementation – (percent of monthly toxic pathology result)		POST-ieMR implementation – (percent of monthly toxic pathology result)		T-statistic (degrees of freedom), p-value
	Mean	Standard deviation	Mean	Standard deviation	
aPTT >110 secs	21.73	1.36	21.05	2.82	-0.75(15.86), p=0.5
aPTT >200 secs	5.31	0.65	5.03	1.16	-0.73(17.36), p=0.5
INR >3.5	8.18	1.50	7.67	1.41	-0.85(21.92), p=0.4
INR >5.5	0.73	0.24	0.71	0.31	-0.17(20.75), p=0.9
Anti-factor Xa >1	30.37	15.26	24.29	12.77	-1.06(21.34), p=0.3

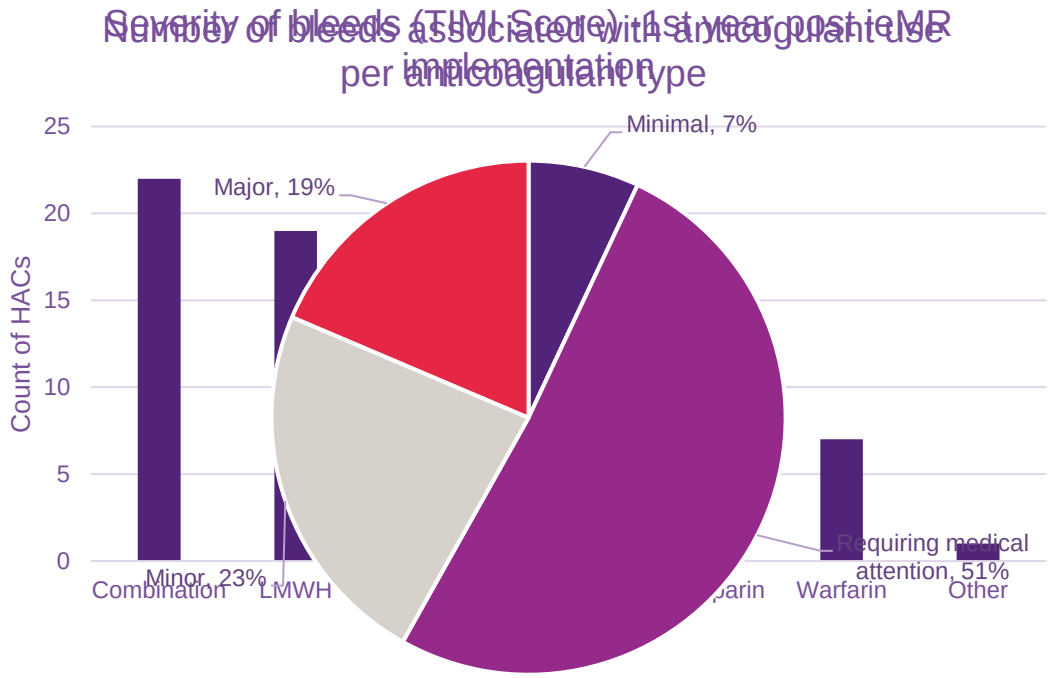
Bleeds associated with anticoagulant use

Hospital-Acquired Complications (10.2) – *'haemorrhagic disorder due to circulating anticoagulants'*

Hospital Acquired Complications (HACs)	PRE-ieMR implementation HACs per month		POST-ieMR implementation HACs per month		T-statistic (degrees of freedom), p-value
	Mean	Standard deviation	Mean	Standard deviation	
Bleeds associated with anticoagulants use	12.1	4.4	7.8	3.5	-2.6 (21.0), p=0.01

Deep Dive – Post ieMR

- n = 87 (started with 93 – excluded 6)

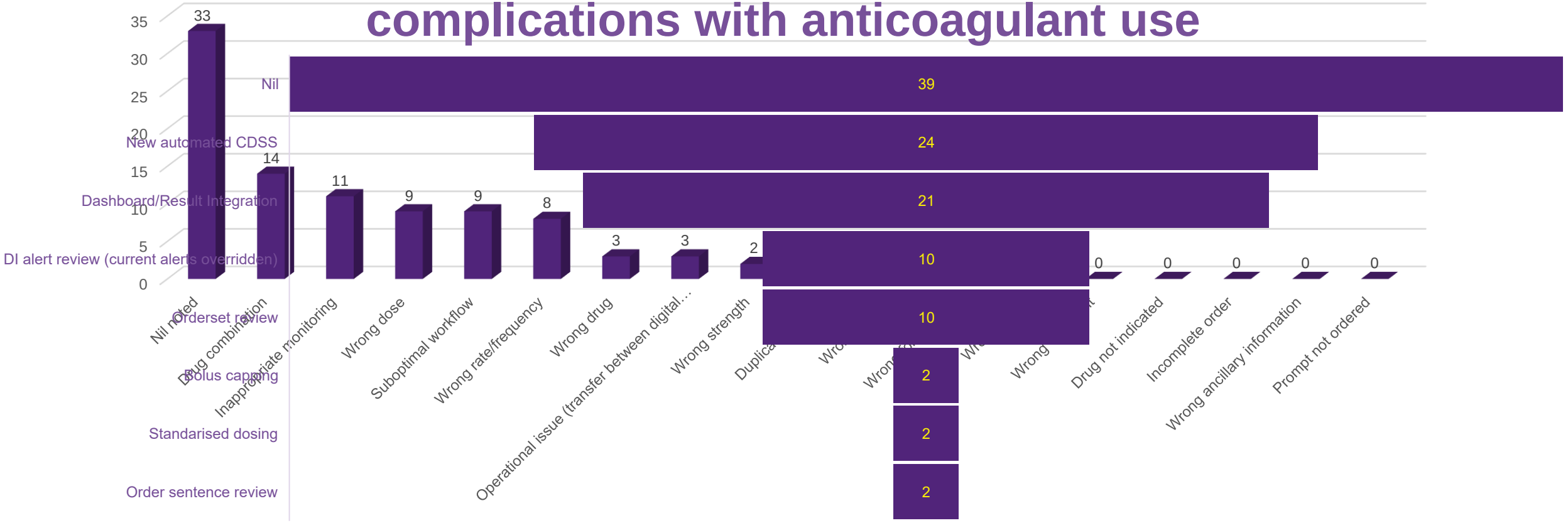


Characteristic		Count	Percentage
Age	20 – 24	1	1.1
	25 - 29	1	1.1
	30 - 34	1	1.1
	35 - 39	1	1.1
	40 - 44	1	1.1
	45 - 49	3	3.4
	50 - 54	6	6.9
	55 - 59	7	8.0
	60 - 64	7	8.0
	65 - 69	11	12.6
	70 - 74	7	8.0
	75 - 79	17	19.5
	80 - 84	16	18.4
	85+	9	10.3
Sex	Male	45	51.7
	Female	42	48.3
Anticoagulant responsible for bleed	IV heparin	17	19.5
	SC heparin	10	11.5
	Warfarin	7	8.0
	LMWH	19	21.8
	DOAC	11	12.6
	Other	1	1.1
	Combination	22	25.3
Indication for anticoagulant	ACS	16	18.4
	AF	13	14.9
	DVT/PE/embolism	29	33.3
	VTE prophylaxis	14	16.1
	Warfarin bridging	6	6.9
	MVR/AVR	5	5.7
	Intra-op (cardiac surgery)	4	4.6
Concurrent antiplatelet/s*	No	44	50.6
	Yes	43	49.4
Concurrent thrombolytic**	No	84	96.6
	Yes	3	3.4
Transfusion required	No	58	66.7
	Yes	29	33.3
TIMI score	Minimal	7	8.0
	Requiring medical attention	44	50.6
	Minor	20	23.0
	Major	16	18.4
Hospital death associated with bleed	No	84	96.6
	Yes	3	3.4

Deep Dive – Post ieMR

Hospital-Acquired Complications (10.2) – *'haemorrhagic disorder due to circulating anticoagulants'*

Potential ieMR enhancements to improve bleeding complications with anticoagulant use

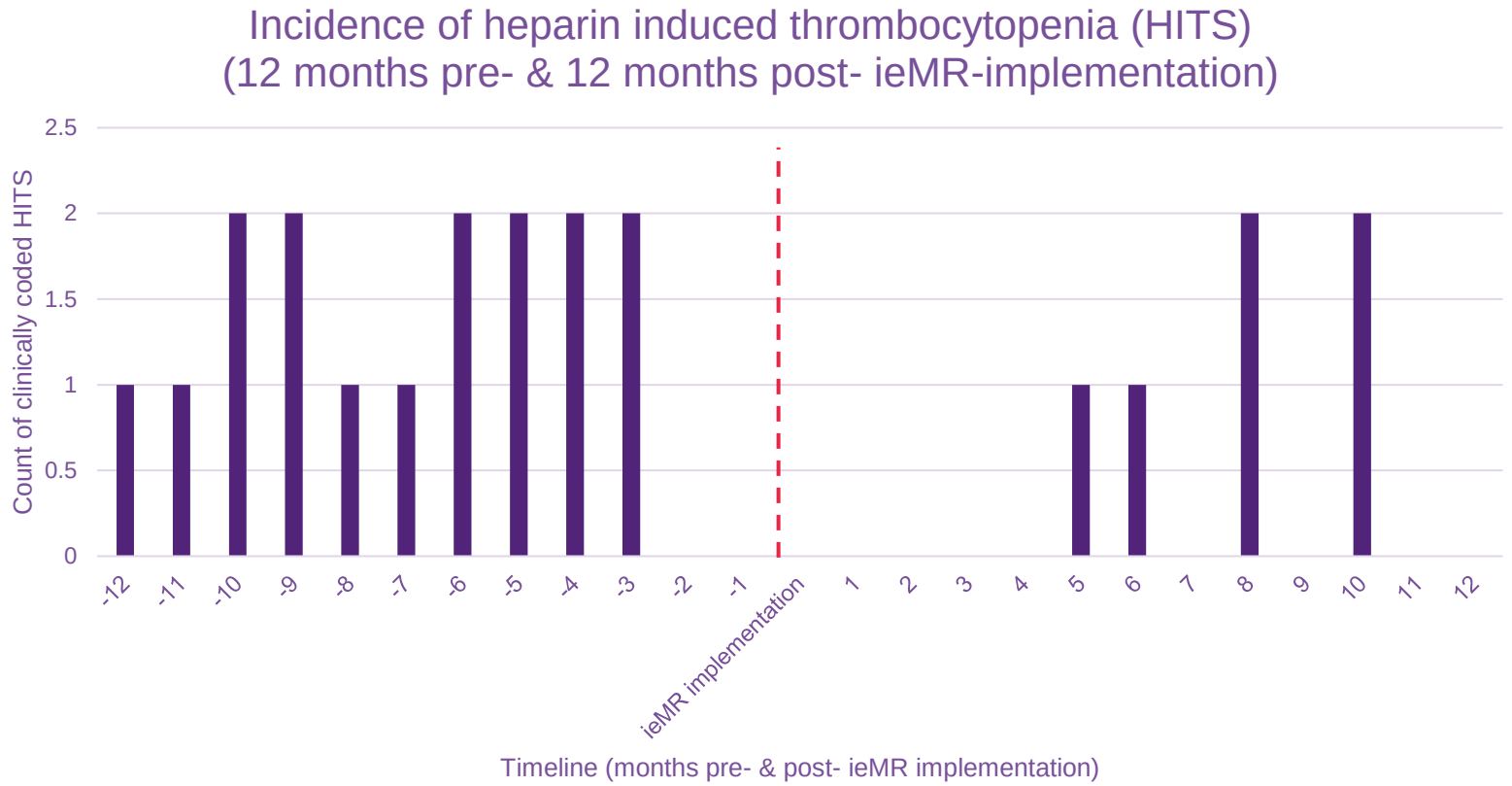


Heparin-induced thrombocytopenia

Clinically coded - (D code D69.5 – ‘’secondary thrombocytopenia’ in conjunction with Y code Y44.2 ‘adverse drug event associated with anticoagulant use’)

Pre-ieMR n = 16 vs.

Post-ieMR n = 6

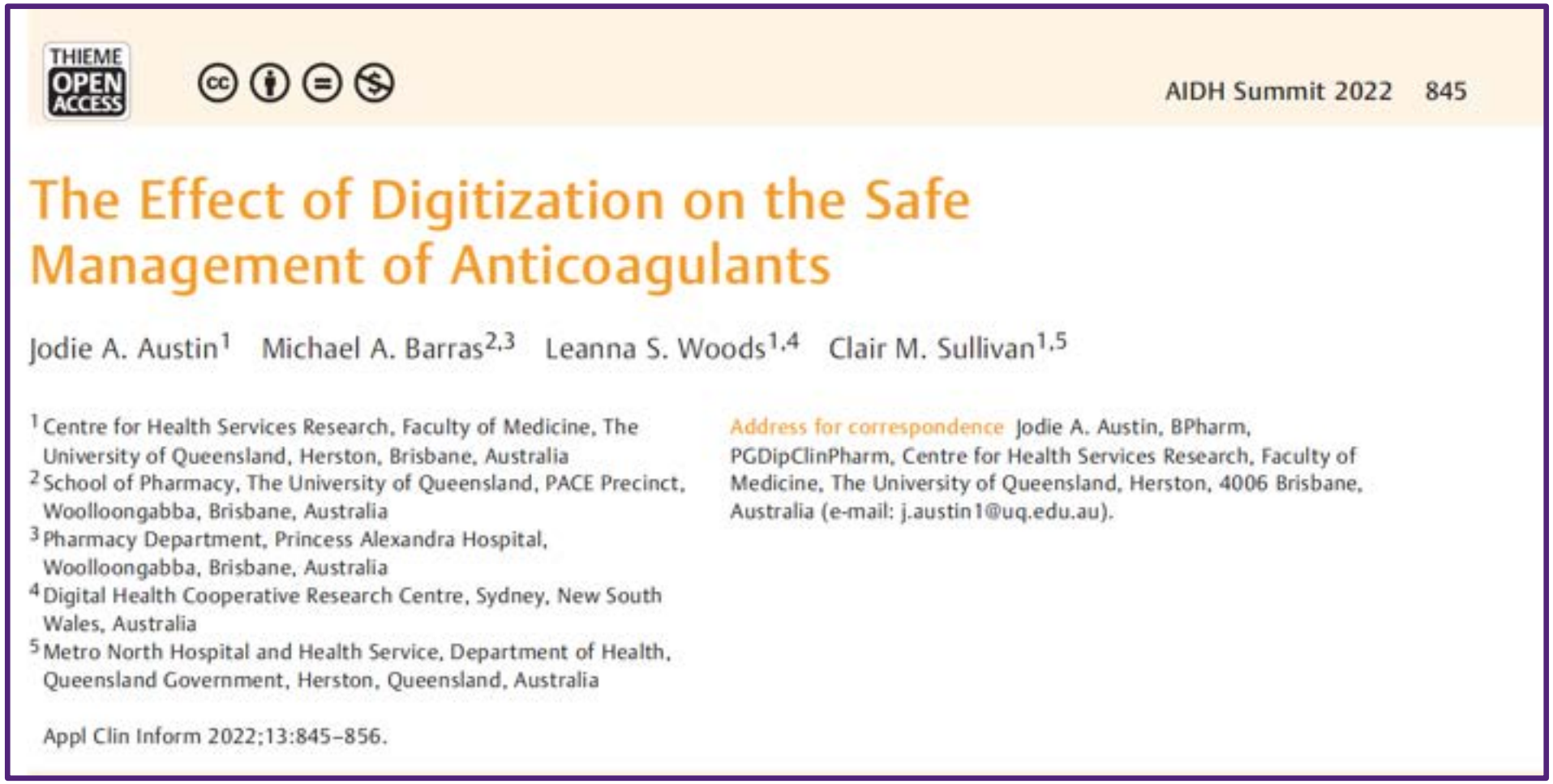


iPharmacy Supply Comparisons

Anticoagulant class	PRE-implementation monthly dose unit mean/ (standard deviation)	POST-implementation monthly dose unit mean (standard deviation)	t-statistic (degrees of freedom)	p-value
IV UFH	877.5 (186.8)	813.5 (148.2)	t(20.9) -0.93	p=0.36
LMWH	3192.4 (374.8)	3400.8 (371.3)	t(22.0) 1.37	p=0.19
DOAC	6512.9 (845.4)	7860.0 (757.1)	t(21.7) 4.11	p=0.0005
Warfarin	8810.5 (1649.3)	8105.1 (1178.9)	t(19.9) -1.21	p=0.24

Further detail:

Austin, J. A., Barras, M. A., Woods, L. S., & Sullivan, C. M. The effect of digitization on the safe management of anticoagulants. Appl Clin Inform 2022;13(4):845–856



THIEME OPEN ACCESS

The Effect of Digitization on the Safe Management of Anticoagulants

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Appl Clin Inform 2022;13:845–856.

Next Steps…

Horizon 2 –

Leveraging the real-time data

Can we create a clinical analytics tool to flag anticoagulated patients at risk?

Can we integrate such a tool into clinical workflows?

What does the literature say?

Toward a Learning Health Care System: A Systematic Review and Evidence-Based Conceptual Framework for Implementation of Clinical Analytics in a Digital Hospital

Han Chang Lim[1,2,*] Jodie A. Austin[1,2,*] Anton H. van der Vegt[3,*] Amir Kamel Rahimi[1,4] Oliver J. Canfell[1,4,5] Jayden Mifsud[1] Jason D. Pole[1] Michael A. Barras[6,7] Tobias Hodgson[5] Sally Shrapnel[1,8] Clair M. Sullivan[1,9]

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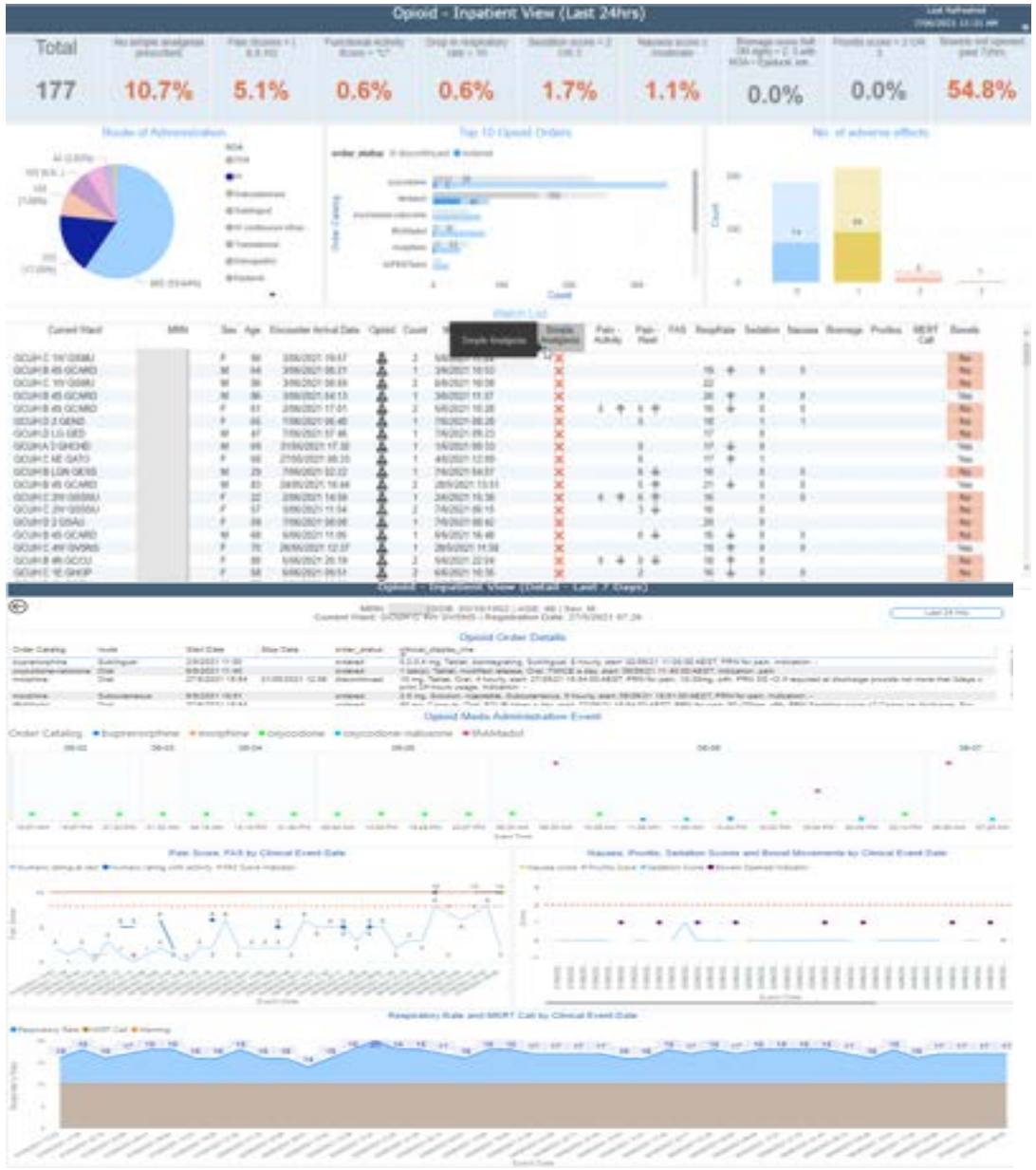
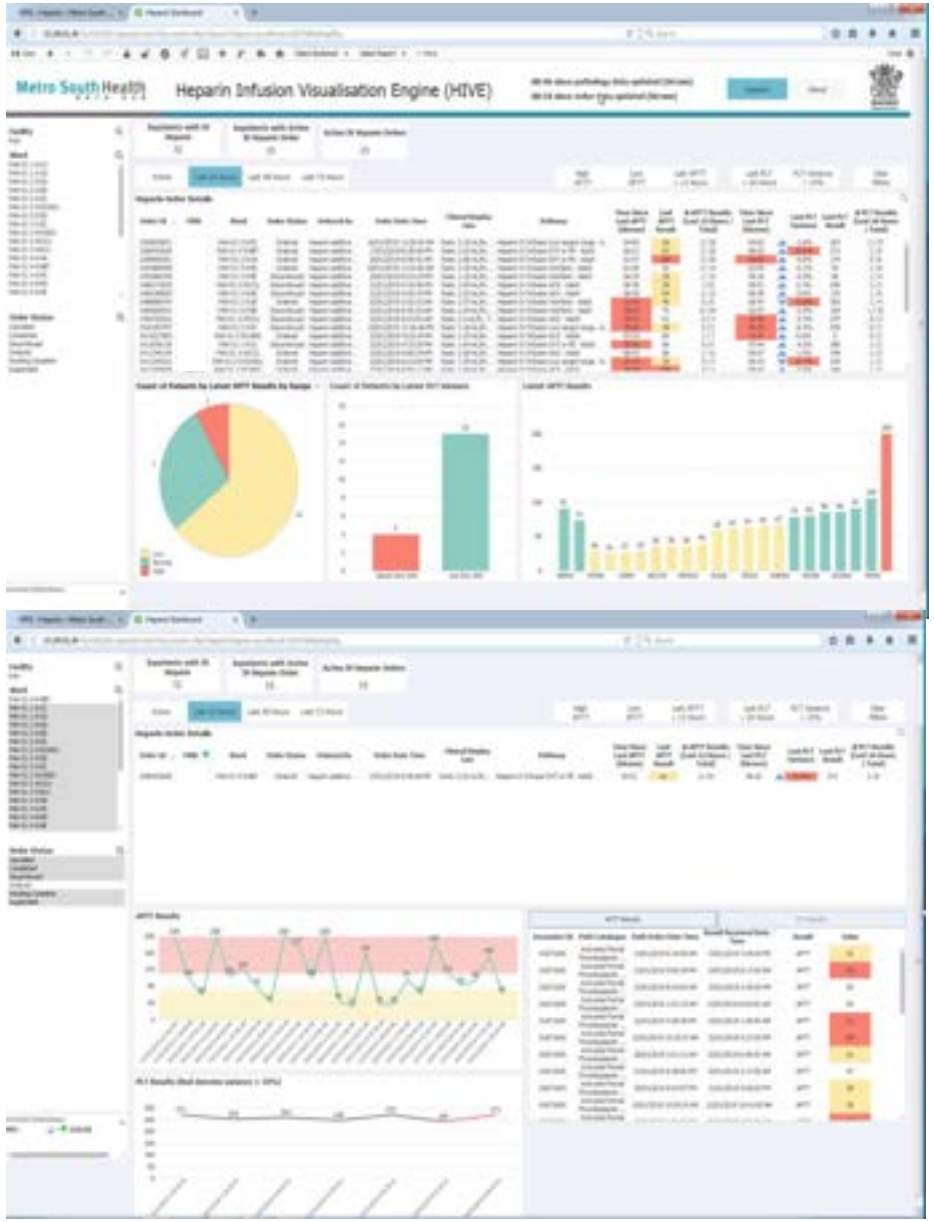
Appl Clin Inform

- n = 14
- 7 previous systematic reviews analysed
- 71 implementation challenges identified
  - Dashboard engineering: financial/human resourcing costs, quantity of data, display in real-time
  - Re-engineering new models of care: clinician resistance, clinical responsibility/disagreement issues
- 72 methods to overcome challenges identified
  - Prototyping, human-centred design, multi-disciplinary design panels
- Scarcity of clinical outcome assessment (n = 4)

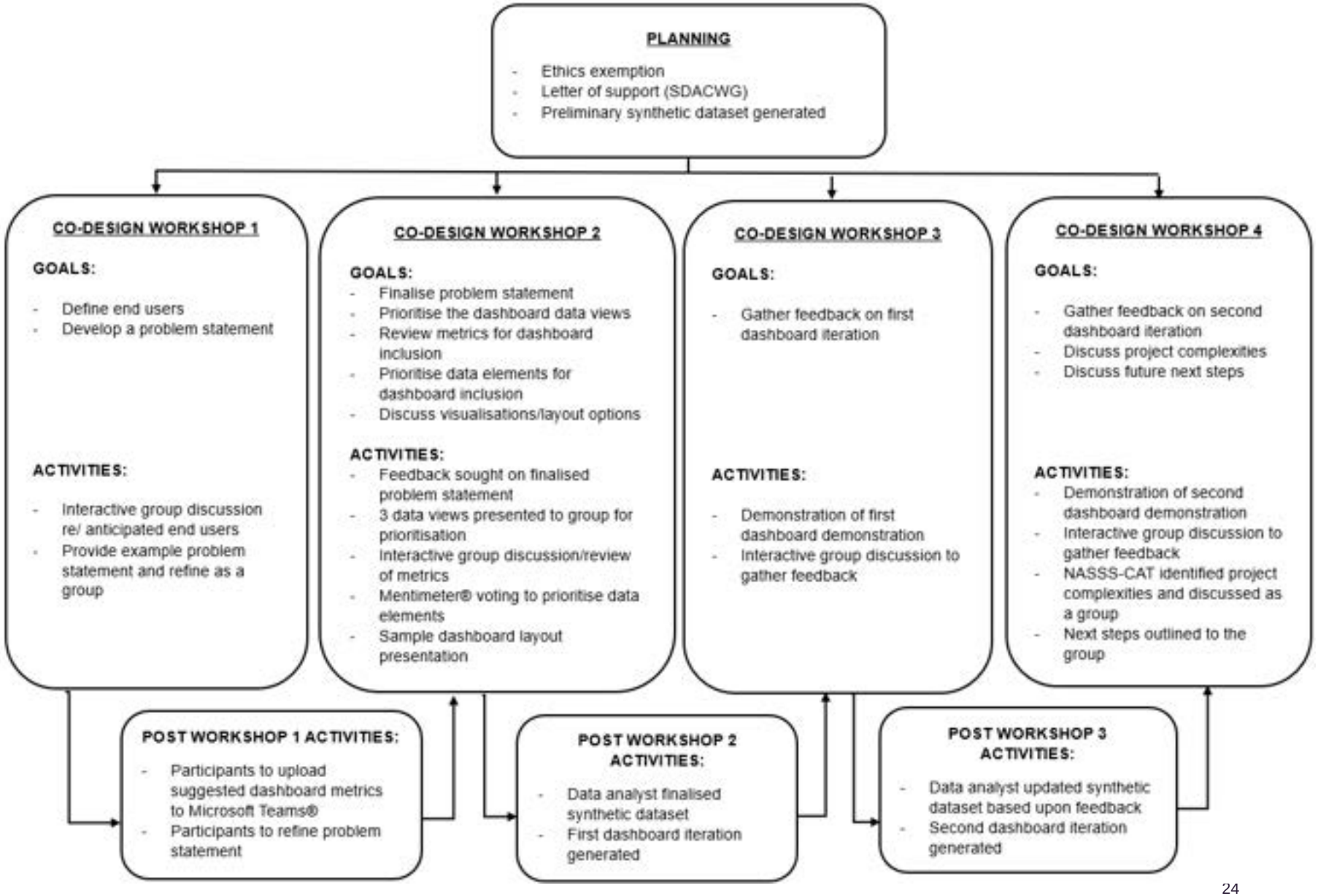
Early medication analytics products





Harnessing the Data

- **Human-centred design approach**
- **Co-design workshops with the QH Statewide Digital Anticoagulation Working Group**
- **NASSS framework**



NASSS Framework

NASSS-CAT (SHORT) Identifying complexities in your technology project

Name of your project: State-wide Digital Anticoagulation Quality and Safety Dashboard

Nonadoption, abandonment, scale-up, spread, and sustainability framework

THE TECHNOLOGY

Think about the technology (e.g., a tool or piece of software), and how it might affect care.

	Agree	*Disagree*	*Not applicable or don't know*
There are significant uncertainties in what the technology is (e.g., it hasn't been fully developed yet)		X	
There are significant uncertainties in where the technology will come from (e.g., supply chain issues, substitutability)	X		
There are significant uncertainties about the technology's performance and dependability (e.g., bugs, crashing, cutting out)	X		
There are significant uncertainties about the technology's usability and acceptability (e.g., key people don't trust the data it provides)	X		
There are significant technical interdependencies		X	
The technology is likely to require major changes to organisational tasks and routines		X	
The technology (and/or the service model it supports) is likely to change significantly within the next 3-5 years		X	
SUMMARY: The technology has significant complexity which is likely to affect the project's success (Centrally maintained via OCCIO or managed through local HHS data hubs)	*Yes* ☐	*No* X ☐	

THE INTENDED ADOPTERS

Think about who is intended to use the technology and what changes it will bring for them.

	Agree	*Disagree*	*Not applicable or don't know*
There is uncertainty about whether and how patients/citizens will adopt the technology [if applicable]		X	
There is uncertainty about whether and how front-line staff will adopt the technology	X		
There is uncertainty about the implications for people who might be indirectly affected by the technology	X		
There will be significant changes to individual users' perceptions of the technology over the next 3-5 years			X
SUMMARY: There is significant complexity relating to intended adopters which is likely to affect the project's success	*Yes* X	*No* ☐	

Greenhalgh T, Maylor H, Shaw S, Wherton J, Papoutsi C, Betton V, et al. The NASSS-CAT Tools for Understanding, Guiding, Monitoring, and Researching Technology Implementation Projects in Health and Social Care: Protocol for an Evaluation Study in Real-World Settings. JMIR Res Protoc. 2020;9(5):e16861.

Co-design principles (Blomkamp, 2018)

1. Outcomes-focused
2. Inclusive
3. Participative
4. Respectful
5. Adaptive

Problem Statement

“Clinicians need a way to be able to view clinical safety and quality issues surrounding anticoagulant use,

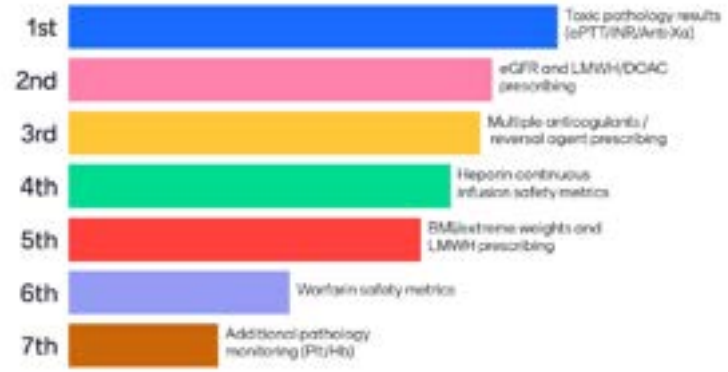
HOWEVER,

Members to date, do not have access to real-time and historic display of relevant findings and associated risks in an aggregated manner.”

Harnessing the Data

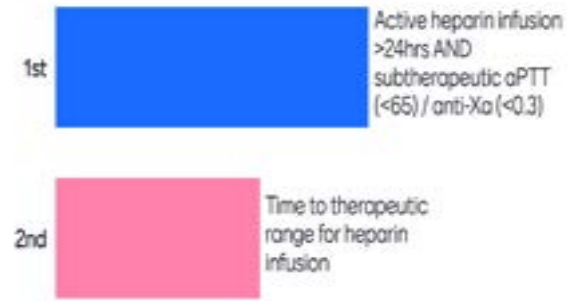
- **State-wide near real-time clinical analytics tool development**

Rank Overarching Themes

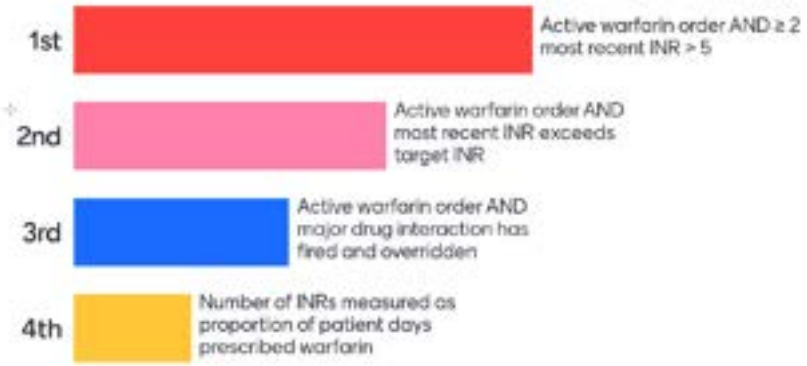


Rank LMWH/DOAC metrics

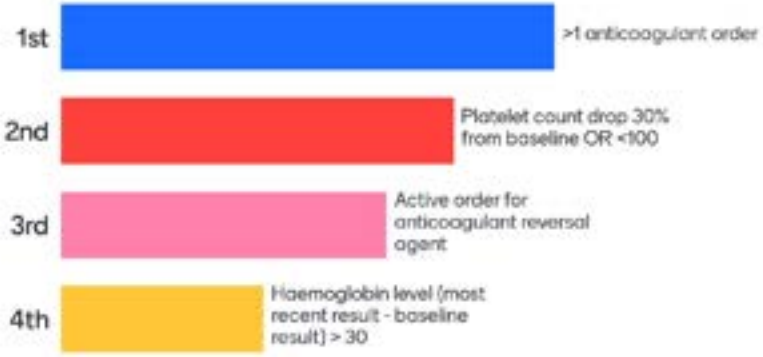
Rank IV Heparin Metrics



Rank Warfarin Metrics



Rank 'Other' Metrics

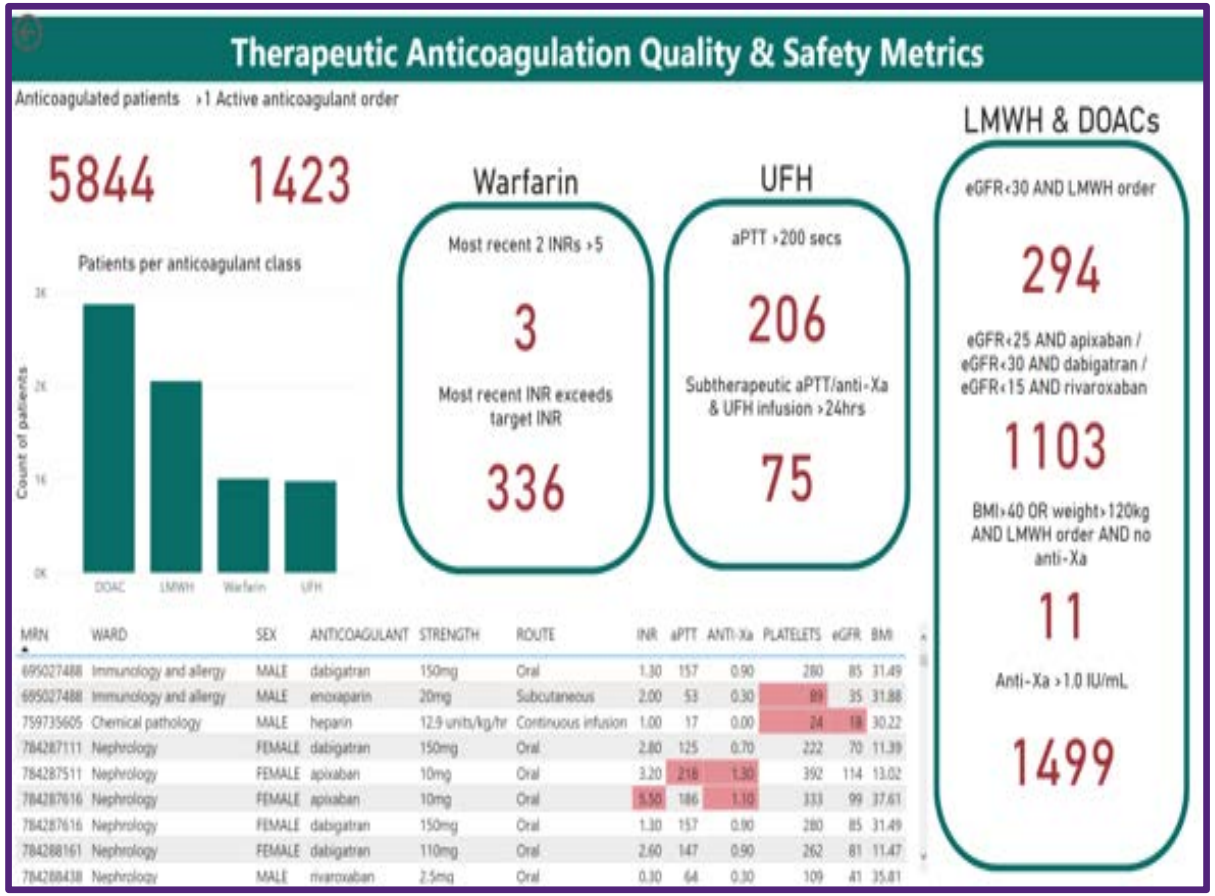


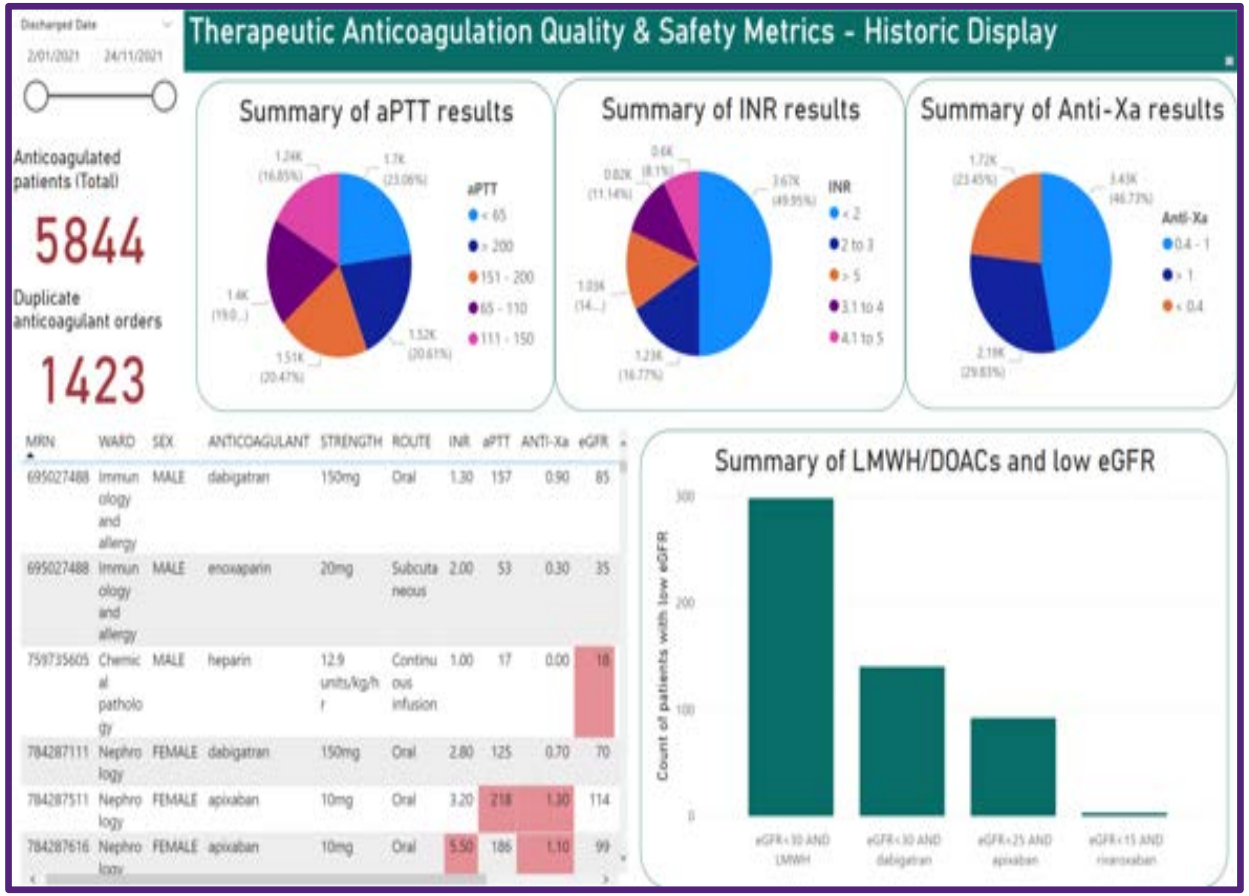
Synthetic Dataset

- **Information generated artificially from computer simulations or algorithms which does not represent events or objects in the real world**

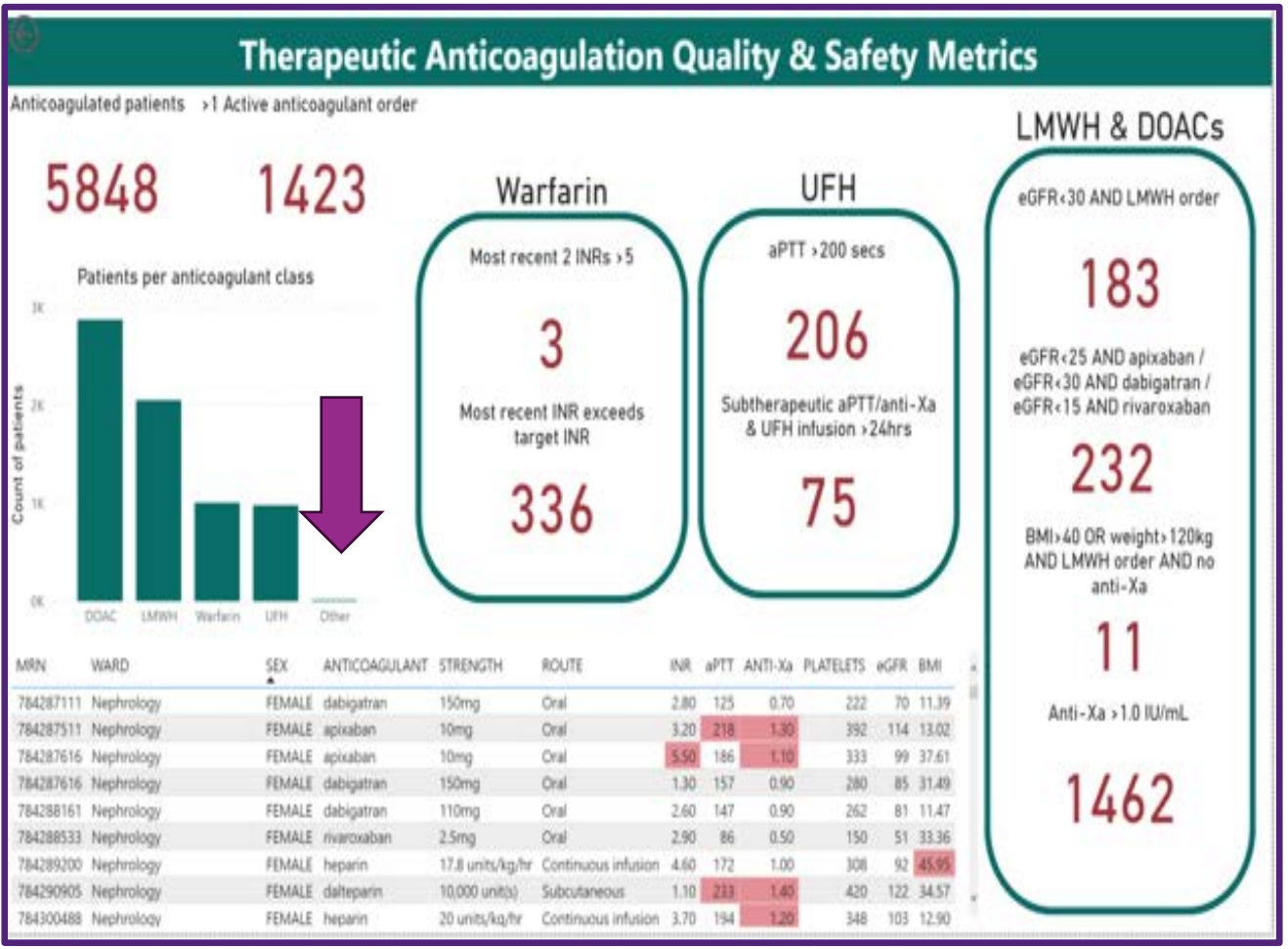
ENCNTR_ID	FACILITY	ADMIT_DT_TM	DISCH_DT_TM	MEDICATION_C	STRENGTH	ROUTE	aPTT	RESULT_DT_TM	INR	AN	eGFR	PLATELET	HAEMOGLOBIN	AGE	BMI	HEIGH	WEIGHT	TARGET_INR	MED_ADMINISTRA	ORDER_TYPE
695027488	Spring Fo	29/01/2021 12:24	1/07/2021 10:50	dabigatran	150mg	Oral	157	1/03/2021 17:54	1.3	0.9	85	280	126	48	31.49	134.37	56.86		8/06/2021 17:54	standard order
695027488	Spring Fo	29/01/2021 12:24	1/07/2021 10:50	enoxaparin	20mg	Subcutaneous	53	1/03/2021 17:54	2	0.3	35	89	72	48	31.88	116.96	43.61		8/06/2021 17:54	standard order
759735605	Spring Fo	4/01/2021 11:13	24/11/2021 23:59	heparin	12.9 units/kg/hr	Continuous infusion	17	27/01/2021 16:43	1	0	18	24	53	72	30.22	102.83	31.95		9/06/2021 16:43	Heparin IV Infusion Warfarin
784287111	Spring Fo	1/01/2021 0:28	3/01/2021 2:10	dabigatran	150mg	Oral	125	2/01/2021 0:58	2.8	0.7	70	222	110	19	11.39	182.8	38.05		3/01/2021 0:58	standard order
784287511	Spring Fo	1/01/2021 0:48	3/01/2021 5:37	apixaban	10mg	Oral	218	2/01/2021 14:18	3.2	1.3	114	392	158	31	13.02	174.33	39.57		3/01/2021 4:18	standard order
784287616	Spring Fo	1/01/2021 0:51	3/01/2021 9:57	dabigatran	150mg	Oral	157	2/01/2021 6:21	1.3	0.9	85	280	126	29	31.49	134.37	56.86		3/01/2021 6:21	standard order
784287616	Spring Fo	1/01/2021 0:51	3/01/2021 9:57	apixaban	10mg	Oral	186	2/01/2021 11:51	5.5	1.1	99	333	141	29	37.61	135.27	68.81		2/01/2021 12:51	standard order
784288161	Spring Fo	1/01/2021 1:25	3/01/2021 10:35	dabigatran	110mg	Oral	147	2/01/2021 20:25	2.6	0.9	81	262	121	17	11.47	166.87	31.94		2/01/2021 21:25	standard order
784288438	Spring Fo	1/01/2021 1:35	3/01/2021 5:55	rivaroxaban	2.5mg	Oral	64	2/01/2021 12:05	0.3	0.3	41	109	78	18	35.81	111.51	44.53		3/01/2021 2:05	standard order
784288533	Spring Fo	1/01/2021 1:40	3/01/2021 8:39	rivaroxaban	2.5mg	Oral	86	2/01/2021 21:10	2.9	0.5	51	150	89	54	33.36	125.86	52.84		2/01/2021 22:10	standard order
784288705	Spring Fo	1/01/2021 14:00	5/01/2021 4:00	dabigatran	110mg	Oral	146	3/01/2021 10:00	1.7	0.9	80	260	121	65	29.54	143.72	61.02		5/01/2021 0:00	standard order
784288705	Spring Fo	1/01/2021 14:00	5/01/2021 4:00	dalteparin	10,000 unit(s)	Subcutaneous	243	3/01/2021 10:00	7.6	1.5	127	438	171	65	32.71	166.03	90.18		5/01/2021 0:00	standard order
784288722	Spring Fo	1/01/2021 1:50	18/02/2021 11:22	heparin	17.8 units/kg/hr	Continuous infusion	172	12/01/2021 8:50	4.6	1	92	308	134	21	45.95	109.46	55.06		3/02/2021 8:50	Heparin IV Infusion Warfarin
784289100	Spring Fo	1/01/2021 2:07	3/01/2021 8:10	enoxaparin	80mg	Subcutaneous	25	2/01/2021 16:07	0.5	0.1	22	37	57	42	24.65	152.54	57.35		3/01/2021 6:07	standard order
784289200	Spring Fo	1/01/2021 2:12	3/01/2021 10:25	heparin	17.8 units/kg/hr	Continuous infusion	172	2/01/2021 18:12	4.6	1	92	308	134	22	45.95	109.46	55.06		2/01/2021 19:12	Heparin IV Infusion Warfarin
784290905	Spring Fo	1/01/2021 3:34	3/01/2021 12:36	dalteparin	10,000 unit(s)	Subcutaneous	233	2/01/2021 16:04	1.1	1.4	122	420	166	22	34.57	123.28	52.54		3/01/2021 11:04	standard order
784300488	Spring Fo	1/01/2021 0:16	3/01/2021 2:08	heparin	20 units/kg/hr	Continuous infusion	194	2/01/2021 5:46	3.7	1.2	103	348	146	18	12.9	191.85	47.49		3/01/2021 0:46	Heparin IV Infusion Warfarin
784300572	Spring Fo	1/01/2021 0:22	3/01/2021 2:08	dalteparin	5,000 unit(s)	Subcutaneous	243	1/01/2021 12:12	8.2	1.5	127	438	171	20	30.36	178.91	97.17		1/01/2021 16:12	standard order
784300572	Spring Fo	1/01/2021 0:22	3/01/2021 2:08	dalteparin	7,500 unit(s)	Subcutaneous	193	2/01/2021 1:52	2	1.1	103	347	145	20	29.41	149.13	65.4		3/01/2021 1:52	standard order
784303477	Spring Fo	1/01/2021 1:45	8/01/2021 16:19	enoxaparin	80mg	Subcutaneous	25	3/01/2021 18:15	0.5	0.1	22	37	57	71	24.65	152.54	57.35		6/01/2021 18:15	standard order
784303688	Spring Fo	1/01/2021 1:53	1/02/2021 15:34	dabigatran	150mg	Oral	40	28/01/2021 23:23	0.4	0.2	29	66	66	69	31.51	124.26	48.66		29/01/2021 0:23	standard order
784304233	Spring Fo	1/01/2021 2:05	6/01/2021 16:05	warfarin	3mg	Oral	126	5/01/2021 4:05	4.6	0.7	70	224	110	24	34.07	134.87	61.97	2 – 3	6/01/2021 4:05	Warfarin(Coumadin) Adult

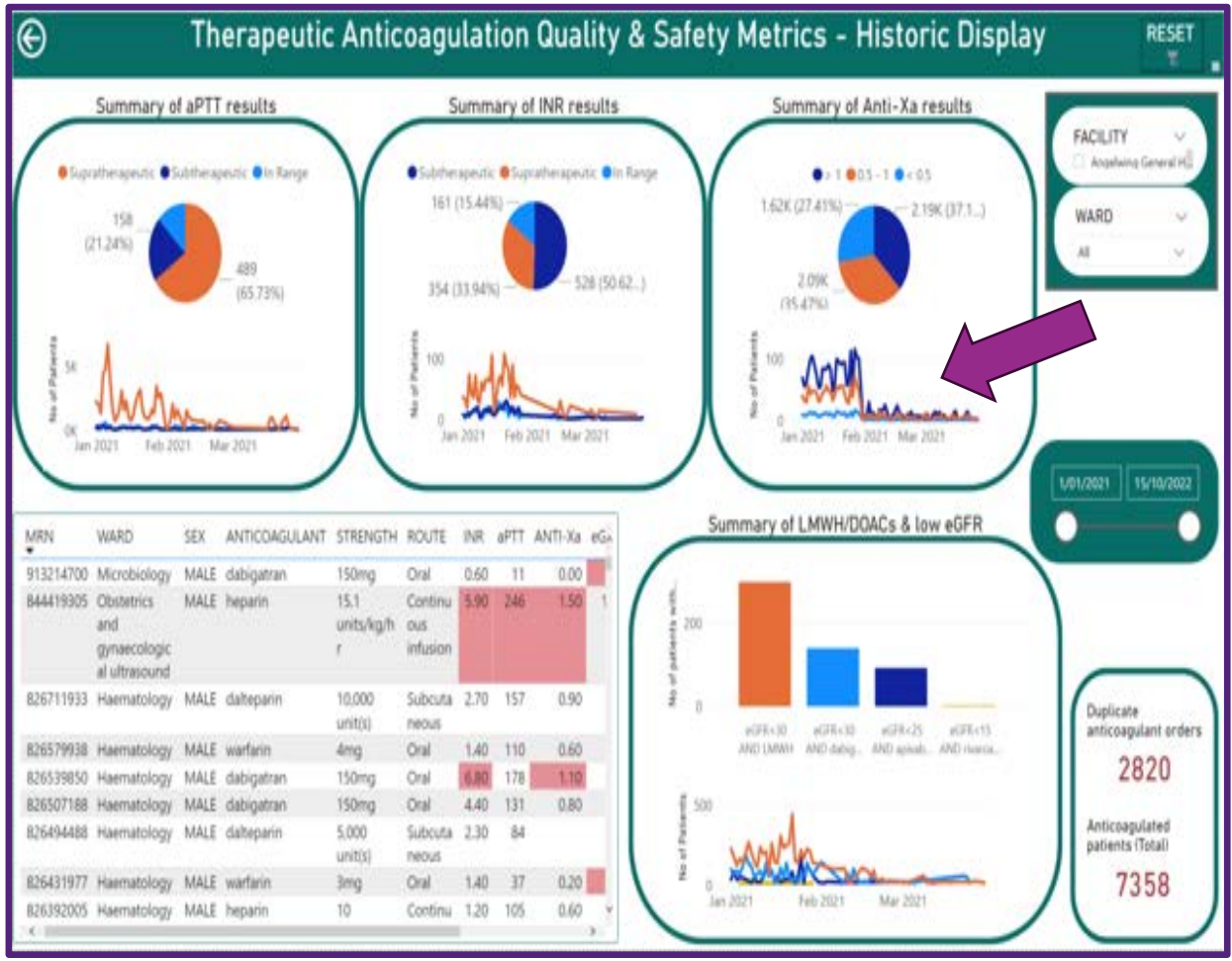
Harnessing the Data



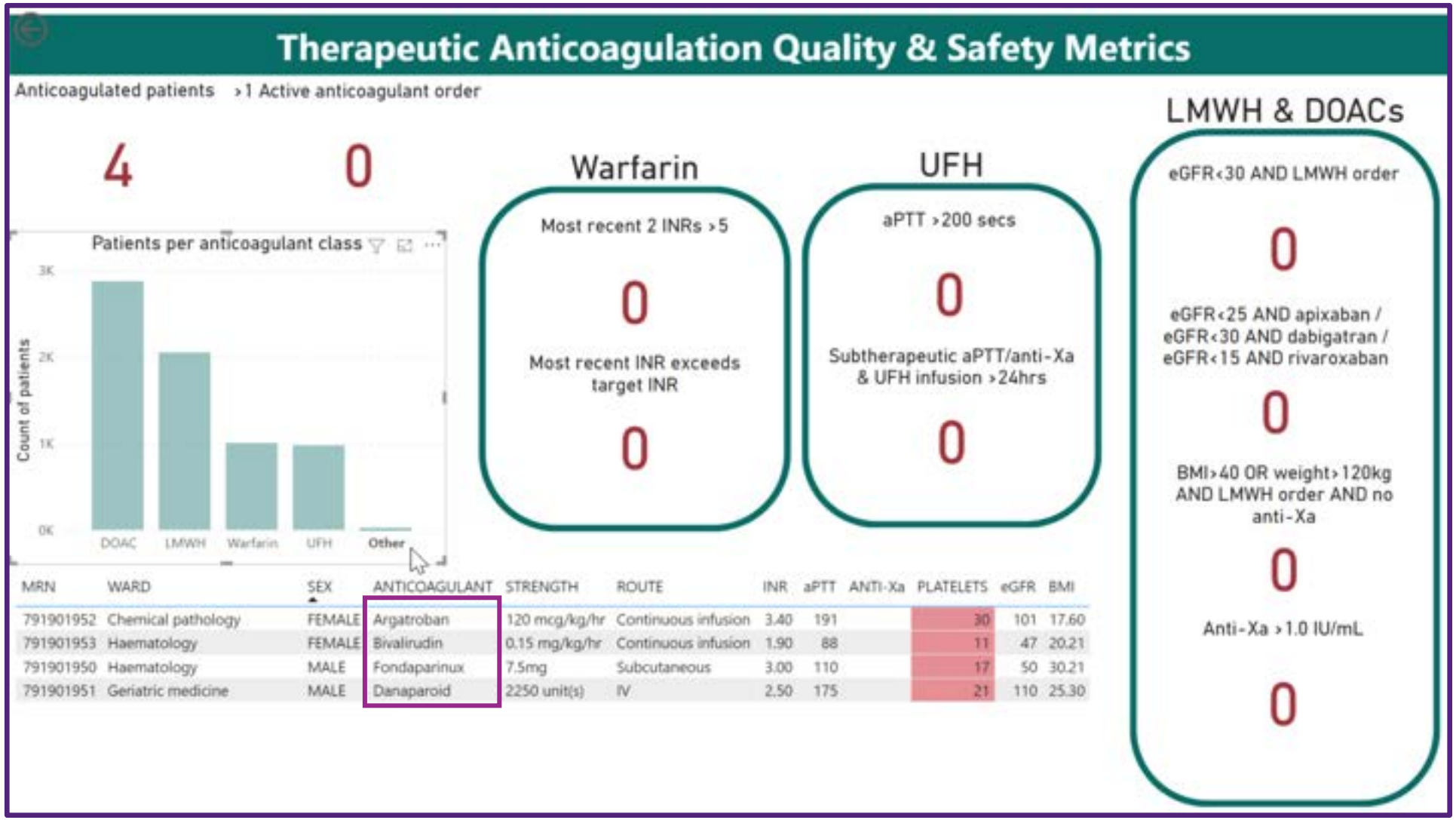


Harnessing the Data





Harnessing the Data



MRN	WARD	SEX	ANTICOAGULANT	STRENGTH	ROUTE	INR	aPTT	ANTI-Xa	PLATELETS	eGFR	BMI
791901952	Chemical pathology	FEMALE	Argatroban	120 mcg/kg/hr	Continuous infusion	3.40	191		30	101	17.60
791901953	Haematology	FEMALE	Bivalirudin	0.15 mg/kg/hr	Continuous infusion	1.90	88		11	47	20.21
791901950	Haematology	MALE	Fondaparinux	7.5mg	Subcutaneous	3.00	110		17	50	30.21
791901951	Geriatric medicine	MALE	Danaparoid	2250 unit(s)	IV	2.50	175		21	110	25.30

Next Steps

- Move proof-of-concept dashboard into QH production environment
- Implementation science – NASSS framework
- A stepped wedge cluster RCT
  - Same evidence-based metrics used in observational study

The end goal.....

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA
CREATE CHANGE

Thank you to the team!

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