

# Decision support in the era of AI:

What have we learnt from electronic decision in clinical systems to drive improvements in safety?

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4<sup>th</sup> April 2019



# Australian Institute of Health Innovation



**Centre for Healthcare Resilience and Implementation Science – *Prof J Braithwaite***

**Centre for Health Informatics – *Prof E Coiera***

**Centre for Health Systems and Safety Research – *Prof J Westbrook***

# Centre for Health Systems & Safety Research



# What impact do electronic clinical systems have on ICU outcomes?



# Systematic Review

- ❖ 20 Studies – 13 moderate quality, 7 weak
- ❖ 11 USA, 4 UK, 5 other
- ❖ No Australian studies

Impact of commercial computerized provider order entry (CPOE) and clinical decision support systems (CDSSs) on medication errors, length of stay, and mortality in intensive care units: a systematic review and meta-analysis

RECEIVED 5 June 2015  
REVISED 9 August 2015  
ACCEPTED 31 August 2015

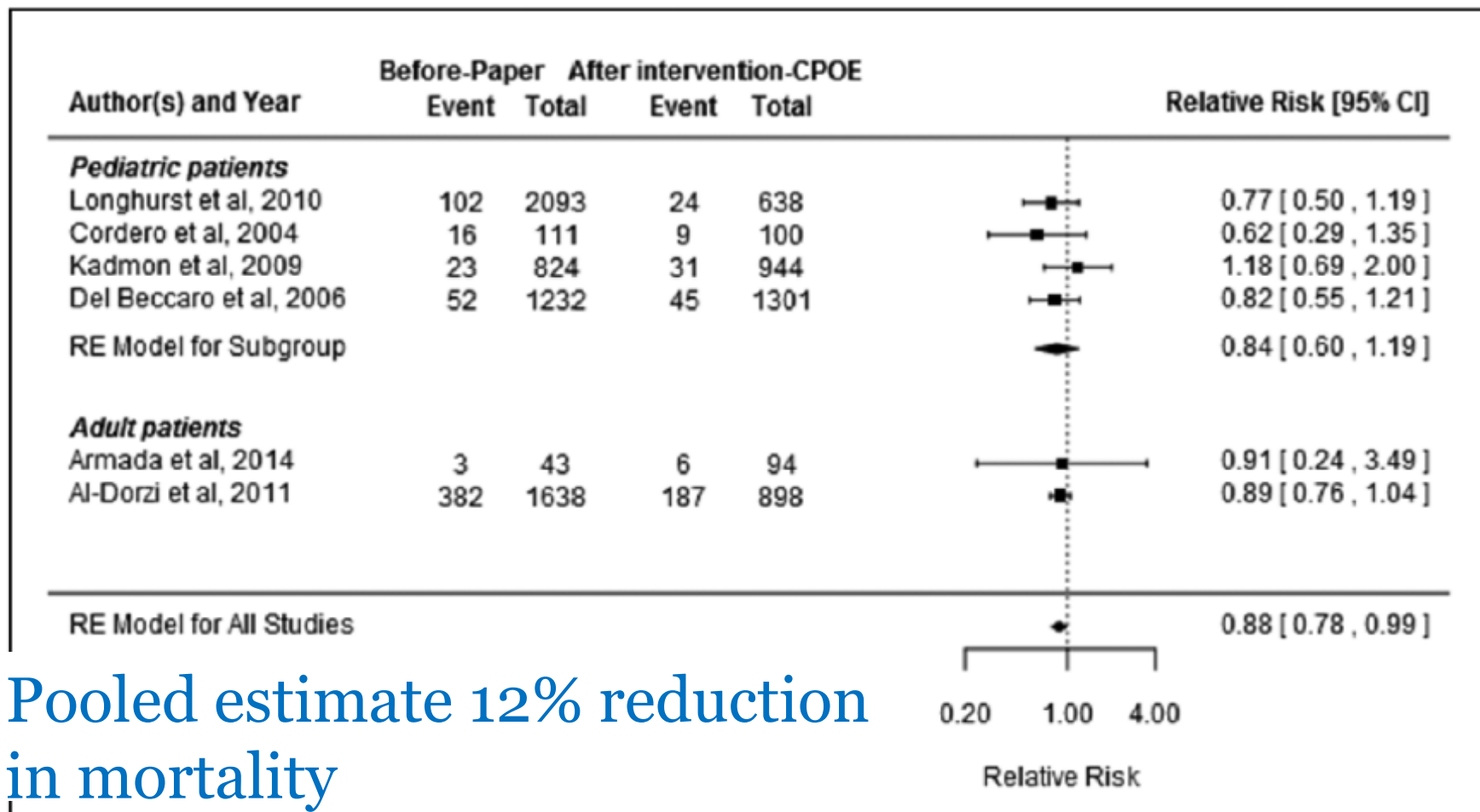
  
INFORMATICS PROFESSIONALS, LEADING THE WAY.

OXFORD  
UNIVERSITY PRESS

Mirela Prgomet<sup>1</sup>, Ling Li<sup>1</sup>, Zahra Niazkhani<sup>2,3</sup>, Andrew Georgiou<sup>1</sup>, and Johanna I Westbrook<sup>1</sup>

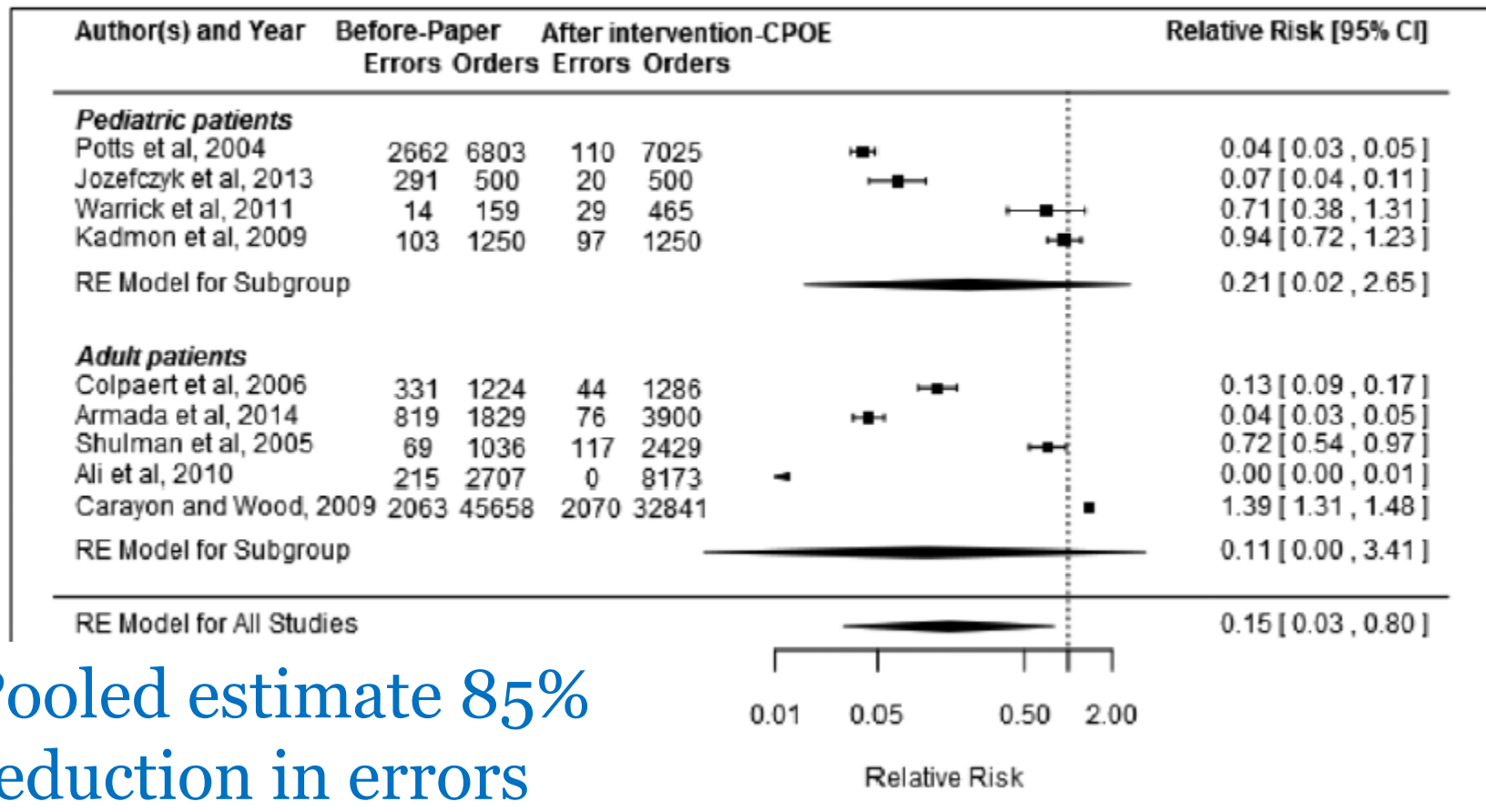
# 6 Studies of ICU mortality pre and post Computerised order entry systems (CPOE) in ICUs

Figure 4: Relative risk of ICU mortality (event indicates number of deaths and total indicates number of patients; RE = random effect).



# 10 Studies of medication errors pre and post Computerised order entry systems (CPOE) in ICUs

Figure 2: Relative risk of medication errors (errors indicates number of errors and orders indicates number of orders audited; RE = random effect).



Pooled estimate 85%  
reduction in errors

# Medication Safety

- International safety challenge
- Global costs associated with medication errors – US\$41 billion annually
- Evidence indicates that electronic medication management systems are highly effective
- Major element in health IT business cases world wide.

WHO Goal:

Reduce severe, avoidable harm related to medications by >50% over 5 years globally



# Do eMM systems reduce medication errors?

## Controlled before/after study



2 Hospitals      2 Systems      6 wards

# Effects of Two Commercial Electronic Prescribing Systems on Prescribing Error Rates in Hospital In-Patients: A Before and After Study

Johanna I. Westbrook<sup>1\*</sup>, Margaret Reckmann<sup>1</sup>, Ling Li<sup>1</sup>, William B. Runciman<sup>2</sup>, Rosemary Burke<sup>3</sup>, Connie Lo<sup>1†</sup>, Melissa T. Baysari<sup>4</sup>, Jeffrey Braithwaite<sup>5</sup>, Richard O. Day<sup>6</sup>

January 2012 | Volume 9 | Issue 1 | e1001164



**Sample:** 3200 patient admissions; >12,000 prescribing errors

Prescribing errors declined by **>50% (p<0.0001)**

**44%** (p=0.0002) reduction in serious prescribing error rate

**25/100** admissions **→** **14/100** adms  
(95%CI 21-29) (95%CI 10-18)

No significant change on the control wards (p=0.4)

# Cost-effectiveness analysis of a hospital electronic medication management system

RECEIVED 24 September 2014  
REVISED 16 October 2014  
ACCEPTED 25 October 2014

Johanna I Westbrook<sup>1</sup>, Elena Gospodarevskaya<sup>2</sup>, Ling Li<sup>3</sup>, Katrina L Richardson<sup>4</sup>,  
David Roffe<sup>5</sup>, Maureen Heywood<sup>6</sup>, Richard O Day<sup>7</sup>, Nicholas Graves<sup>8</sup>



J Am Med Inform Assoc 2015

- eMM – resulted in a reduction of A\$63-66 per admission
- Entire hospital with 39,000 annual admissions = releasing A\$2.5M each year

Is eMM  
the  
Solution?





Stepped wedge cluster randomized controlled trial  
Aim – Assess the impact of eMM in paediatrics including  
harm & cost-effectiveness

# Evidence that targeted decision support can be highly effective

## Dicloxacillin Capsule

### Drug to Allergy/Intolerance Interactions

 Class Allergy to Penicillins  (facial swelling)

*Dicloxacillin Capsule contains Dicloxacillin which is in the class Penicillins to which the patient is allergic.*



Action

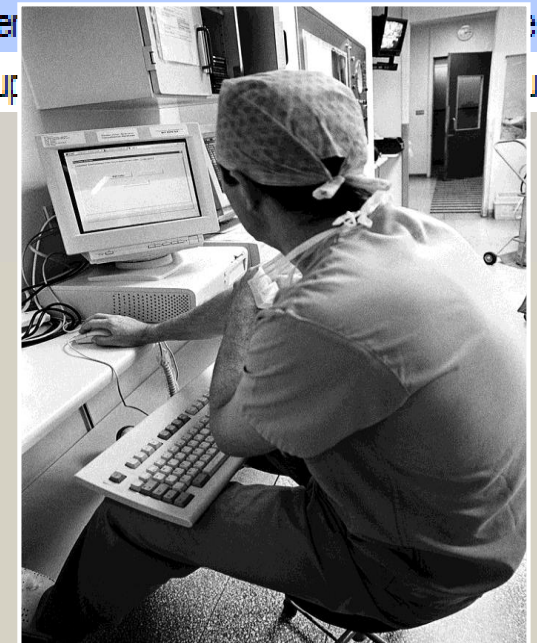
Comment

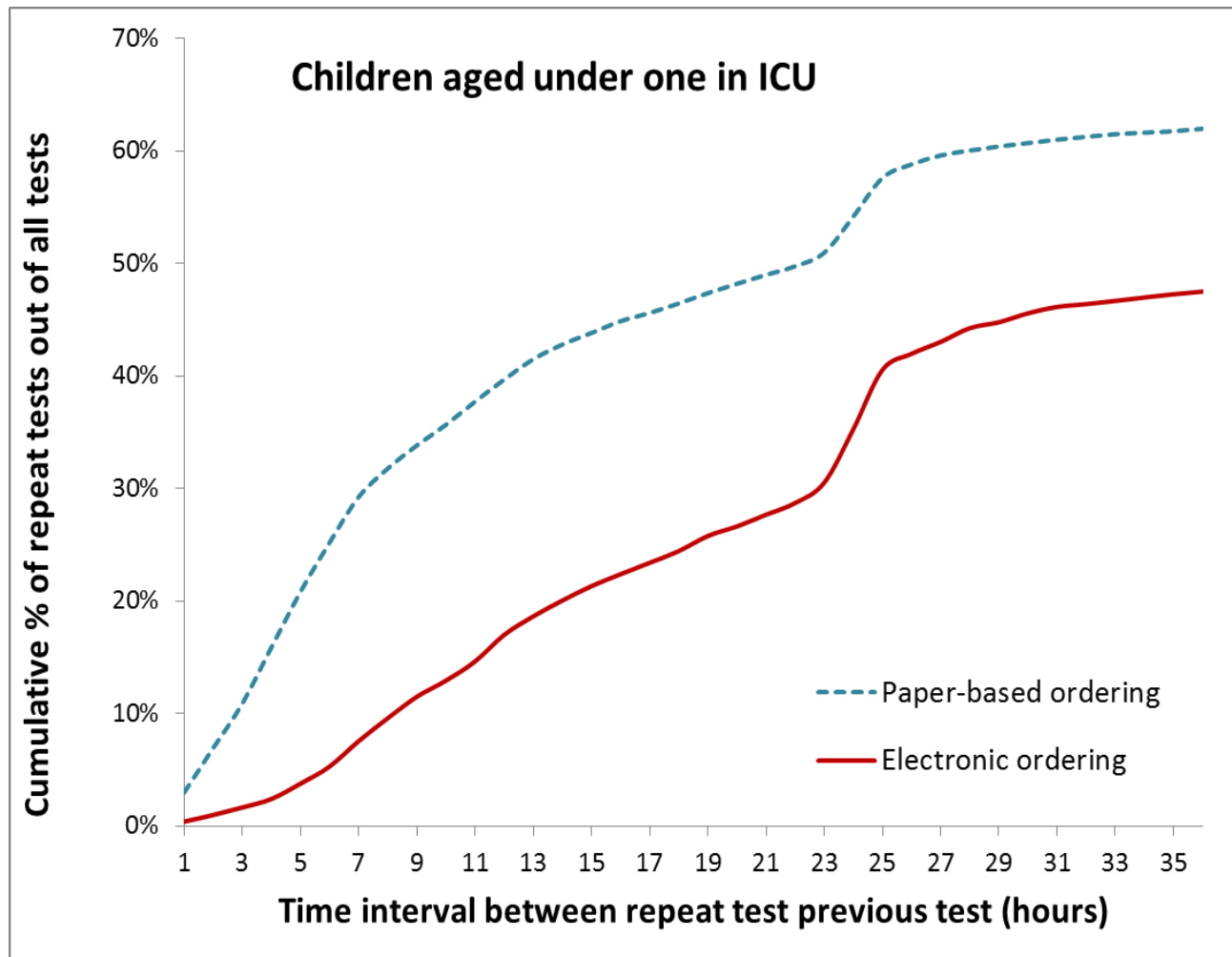
- Override
- Remove

# Impact of decision support on repeat laboratory test ordering rates

**\*\*Duplicate Order Alert\*\***

	Orderable	
	<b>APTT Mixing Studies</b>	Citrate plasma, Req D/T: 21/02/2012 16:17 AEDT, Collected, Follow up prolonged APTT   Liver Disease   Lupus
	APTT Mixing Studies	Citrate plasma, Req D/T: 21/02/2012 16:17 AEDT, Not Collected, Liver Disease   On Warfarin, Priority: Routine
	<b>APTT Mixing Studies</b>	Citrate plasma, Req D/T: 21/02/2012 16:17 AEDT, Not Collected, Liver
	APTT Mixing Studies	Citrate plasma, Req D/T: 21/02/2012 16:17 AEDT, Collected, Follow up






Repeat testing for 5073 children under 1 year in ICUs **significantly** ( $p < 0.0001$ ) **declined** following the introduction of electronic test ordering

*Li et al. 2014 What is the effect of e-pathology ordering on test re-ordering for paediatric patients? Studies in Health Technology and Informatics, 204, IOS press, 74-79.*

# But.....

A large body of work demonstrating that doctors override alerts (i.e. click past alerts without following recommendations), up to **95%** of alerts

 Alert fatigue - mental state resulting from excessive numbers of alerts being triggered

Leads to:

- User frustration and annoyance
- Prescribers overwhelmed by alerts
- Learn to ignore all alerts



# When and why decision support may be effective?



# What impact does eMMS decision support have during ward rounds?

- 58.5 hrs, 14 teams, 96 orders
- 48% of medication orders triggered alerts
- 17% read
- No orders changed



## Research and applications

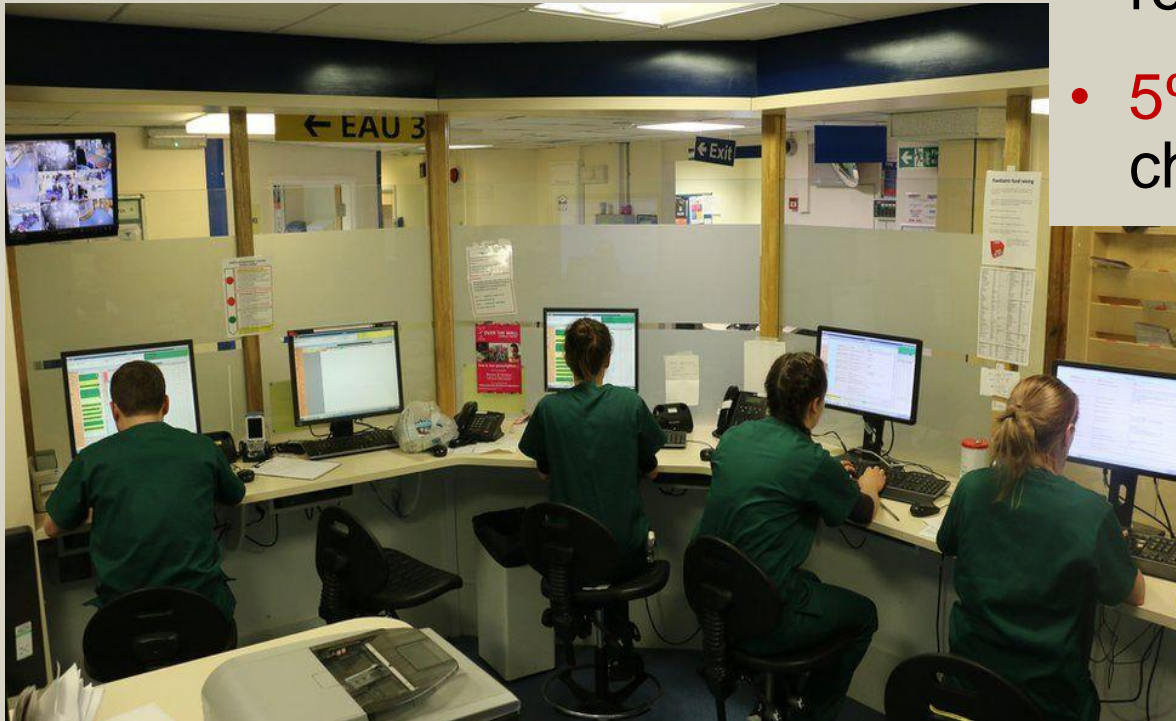
*J Am Med Inform Assoc* 2011;**18**:754–759.

The influence of computerized decision support on prescribing during ward-rounds: are the decision-makers targeted?

Melissa T Baysari,<sup>1</sup> Johanna I Westbrook,<sup>2</sup> Katrina L Richardson,<sup>3</sup> Richard O Day<sup>4,5</sup>

## Junior doctors' response to computerised alerts at night 16:30-22:30

- Observational study - 65 hours
- 78% of alerts were read
- 5% resulted in a change in prescribing



**Context Matters**

### Junior doctors' prescribing work after-hours and the impact of computerized decision support

INTERNATIONAL JOURNAL OF MEDICAL INFORMATICS 82 (2013) 980-986

Samantha L. Jaensch<sup>a,b</sup>, Melissa T. Baysari<sup>b,c,\*</sup>, Richard O. Day<sup>a,b</sup>,  
Johanna I. Westbrook<sup>d</sup>



Patient Note

Created: 17/06/2016 JMK Edited: Locked:

Subject: Drug-Drug Interaction Warning(s)

OK  
Cancel

Font: Arial 9 Bold Italic Underline

Patient Name: TEST, FIVE

----- Warning: Drug-Drug Screening Result(s) -----  
Severity: \*\*\* Severe  
Interaction between AZATHIOPRINE and ALLOPURINOL  
Thiopurines/ALLOPURINOL; OXPURINOL  
CLINICAL EFFECTS: Potentiation of thiopurine effects, with increased bone marrow suppression.

----- <References for Drug-Drug Interactions> -----  
Interaction between AZATHIOPRINE and ALLOPURINOL  
REFERENCES:  
1.Hitchings GH. Summary of informal discussion on the role of purine antagonists. Cancer Res 1963 Sep;23:1218-25.  
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8.Zimm S, Ettinger LJ, Holcenberg JS, Kamen BA, Vietti TJ, Belasco J, Cogliano-Shutta N, Balis F, Lavi LE, Collins JM, et al. Phase I and clinical pharmacological study of mercaptopurine administered as a prolonged intravenous infusion. Cancer Res 1985 Apr;45(4):1869-73.  
9.Cox GJ, Robertson DB. Toxic erythema of palms and soles associated with high-dose mercaptopurine chemotherapy. Arch Dermatol 1986 Dec; 122(12):1413-4.  
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13. Anonymous. Hypertension and the lupus syndrome. Am J Med 1970 Oct; 49(4):519-28.  
14. Purinethol (mercaptopurine) US prescribing information. Gate Pharmaceuticals May, 2011.

Two options

**Design  
is  
critical**

# How do hospitals decide what alerts to implement?

- ❖ Decision support volume increasing
- ❖ Survey of 26 Australian hospitals (*Page N, et al, JPPR, 2018*)
- ❖ All had **Allergy** and **Drug-Drug interaction** checking
- ❖ 69% also had **dose-range** checking

***Configuration decisions fueled by a perception that alerts change prescriber behaviour and improve patient outcomes – But very few local evaluations of their effects***



ELSEVIER

# International Journal of Medical Informatics

journal homepage: [www.elsevier.com/locate/ijmedinf](http://www.elsevier.com/locate/ijmedinf)

## Review article

A systematic review of the effectiveness of interruptive medication prescribing alerts in hospital CPOE systems to change prescriber behavior and improve patient safety

N. Page<sup>a,\*</sup>, M.T. Baysari<sup>a,b</sup>, J.I. Westbrook<sup>a</sup>

*International Journal of Medical Informatics* 105 (2017) 22–30

An evidence-based approach to decision support selection

# Drug-drug Interaction (DDI) Alerts



Large potential number – 100s - >15,000 alerts

Eur J Clin Pharmacol (2018) 74:15–27  
<https://doi.org/10.1007/s00228-017-2357-5>



REVIEW

## Drug-drug interactions and their harmful effects in hospitalised patients: a systematic review and meta-analysis

Wu Yi Zheng<sup>1</sup> • L. C. Richardson<sup>1</sup> • L. Li<sup>1</sup> • R. O. Day<sup>2,3</sup> • J. I. Westbrook<sup>1</sup> •  
M. T. Baysari<sup>1,3</sup>

Eur J Clin Pharmacol (2018) 74:15–27

**15,000 alerts???**

**Does the size of the problem warrant the solution?**

# Study to assess the impact of adding DDI alerts in a hospital electronic medication system

- Prescribed medication orders for all admitted patients at Hospital X on a single day extracted and replicated in a ‘test’ EMM system
- The ‘Test’ system had DDI alerts enabled – moderate, severe, unknown

	Allergy & Intolerance	Dose Range	Local rules	Therapeutic Duplication	DDIs
<b>Alert Condition 1</b> (Live system) Reference condition	✓	✓	✓	✓	✗
<b>Alert Condition 2</b> (Test system)	✓	✓	✓	✓	✓

# Overall alert volume by adding DDIs

Research by Anmol Sandhu at MQ

## Medication orders

Background: 2728

Study date: 576

## Patients

254 admitted inpatients

- 133 had study date medication orders

### Alert Condition 1

209 alerts generated

145 (**25%**)  
medication orders  
generated at least 1  
alert

1.4 alerts per  
medication order  
(range: 0 - 4)

### Alert Condition 2

1063 alerts  
generated

348 (**60%**)  
medication orders  
generated at least 1  
alert

3.1 alerts per  
medication order  
(range: 0 - 11)

### Increase with DDI alerts

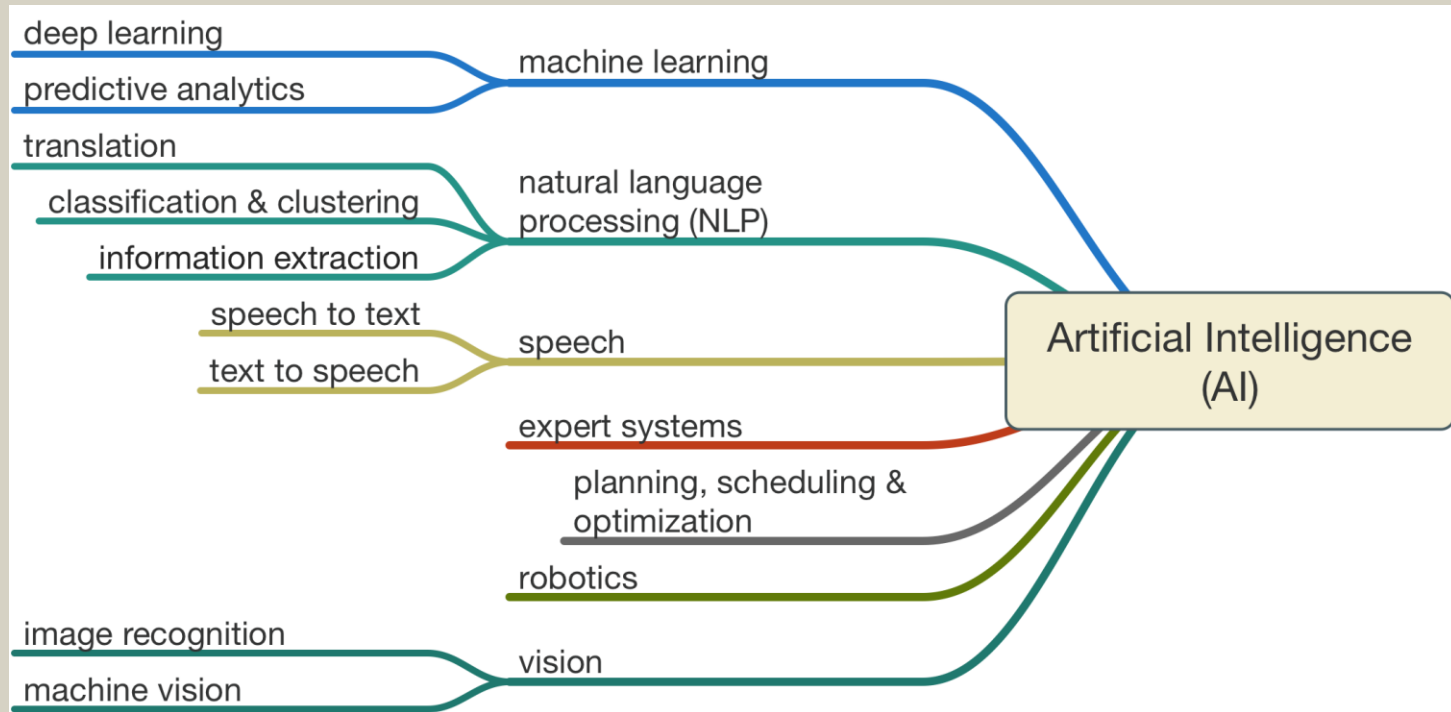
**+509%**

**+240%**

**+212%**

Statistically significant increase with  
DDI alerts ( $p < 0.005$ )

# Next generation of decision support driven by AI approaches



Assisted Intelligence – Helping providers perform tasks faster and better

Augmented intelligence – Helping providers make better decisions

Autonomous intelligence – automating decision making processes without human interventions



In an era of AI driven clinical support many of the challenges of designing effective mechanisms and models for incorporating decision support into clinical workflows remain.

# What can we learn from experiences with Electronic Decision Support ?

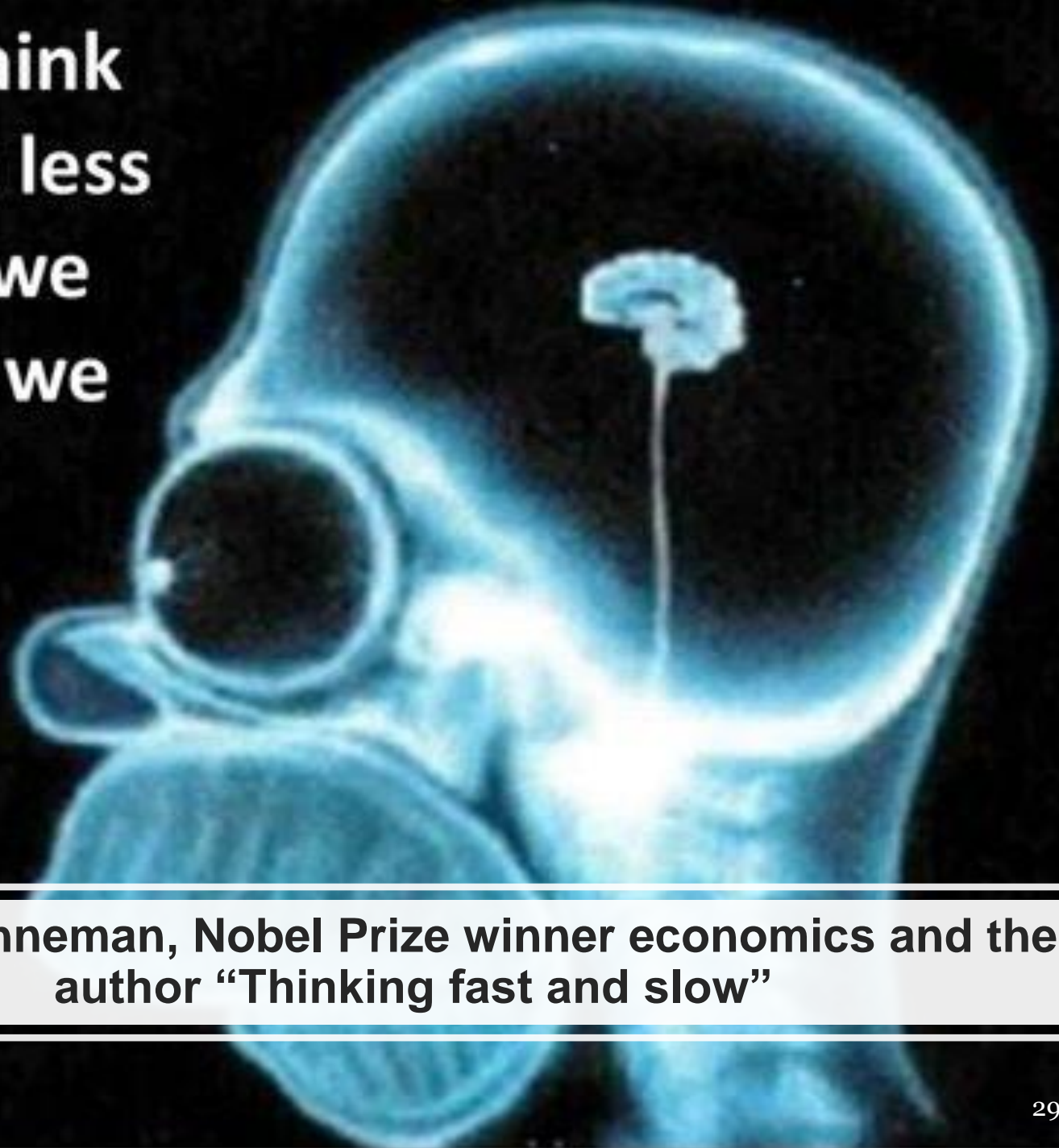
Human Factors Design –  
Critical

Context important -

Behavioural Economics -  
Evidence of how people  
make decisions



**We think  
much less  
than we  
think we  
think**



**Daniel Kahneman, Nobel Prize winner economics and the author “Thinking fast and slow”**

# Research on decision-making



Decision option presentation influences user choice.

- ❖ Providing option to maintain the status quo selected over making a change
- ❖ Items placed first selected more frequently
- ❖ Presenting antibiotic choice grouped according to narrow or broad spectrum, rather than listing individual drugs, resulted in a significant reduction in inappropriate antibiotic use.
- ❖ Tests or medications in an order-set increases use, even in situations when not clinically appropriate.

**How behavioural economics helps us choose.**



# Choice Architecture

NUDGING PEOPLE TO MAKE A 'DESIRABLE'  
CHOICE

# Digital nudging and the future of decision-support

RICHARD H. THALER  
WINNER OF THE NOBEL PRIZE IN ECONOMICS  
and CASS R. SUNSTEIN



## *Nudge*

NEW YORK TIMES Bestseller

Improving Decisions About  
Health, Wealth, and Happiness

"One of the few books . . . that fundamentally changes the way I think about the world." —Steven D. Levitt, coauthor of FREAKONOMICS

# An evidence-based approach to electronic decision support

- ❖ Understanding decision-making context
- ❖ Target support to big safety/quality problems
- ❖ Apply choice architecture and digital nudges
- ❖ Evaluate and monitor both expected and unexpected changes using robust measurement approaches



# Thank You

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