BENEFITS, RISKS AND CHALLENGES OF CLINICAL DECISION SUPPORT SYSTEMS

Prof. dr. apr. Pieter Cornu

PERSONAL BACKGROUND

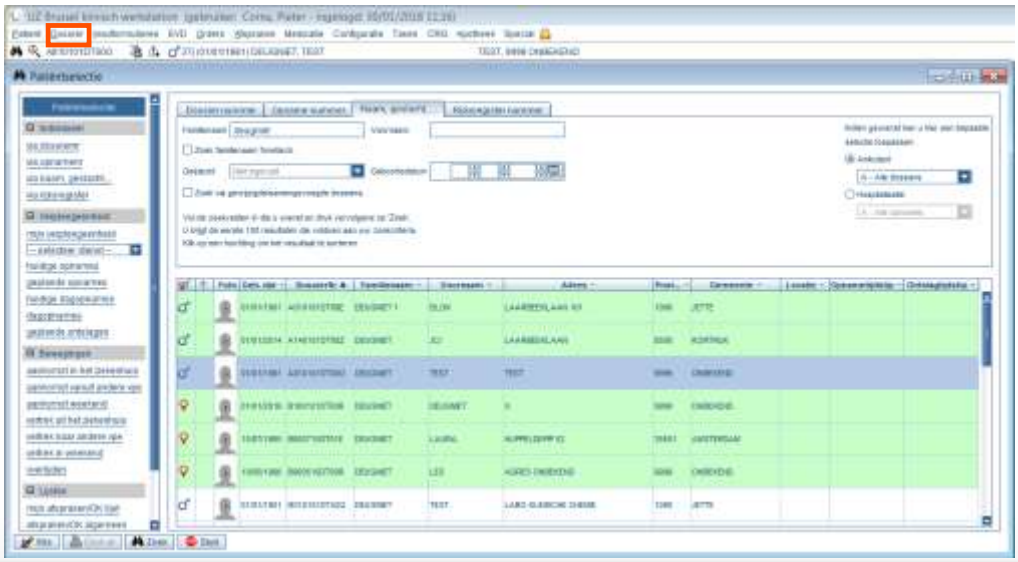
- Appointments:
  - Assistant professor VUB pharmacoepidemiology, eHealth, pharmacology
  - Clinical decision support coordinator UZ Brussel
- Education:
  - Master Pharmaceutical Sciences (VUB, 2009)
  - PhD Pharmaceutical Sciences (VUB, 2015)
  - Master Epidemiology (UA, 2017)
- Research domains:
  - CDS and medical informatics
  - Pharmacoepidemiology
  - Clinical pharmacy

THE WONDERFUL WORLD OF CLINICAL DECISION SUPPORT

Goal of this presentation

- Give an introduction of CDS
  - Focus on medication related CDS
  - Focus on CDS integrated in hospital information systems (HIS)
- Benefits of current CDS
- Risks of current CDS
- Challenges for the future

HOSPITAL INFORMATION SYSTEM UZ BRUSSEL



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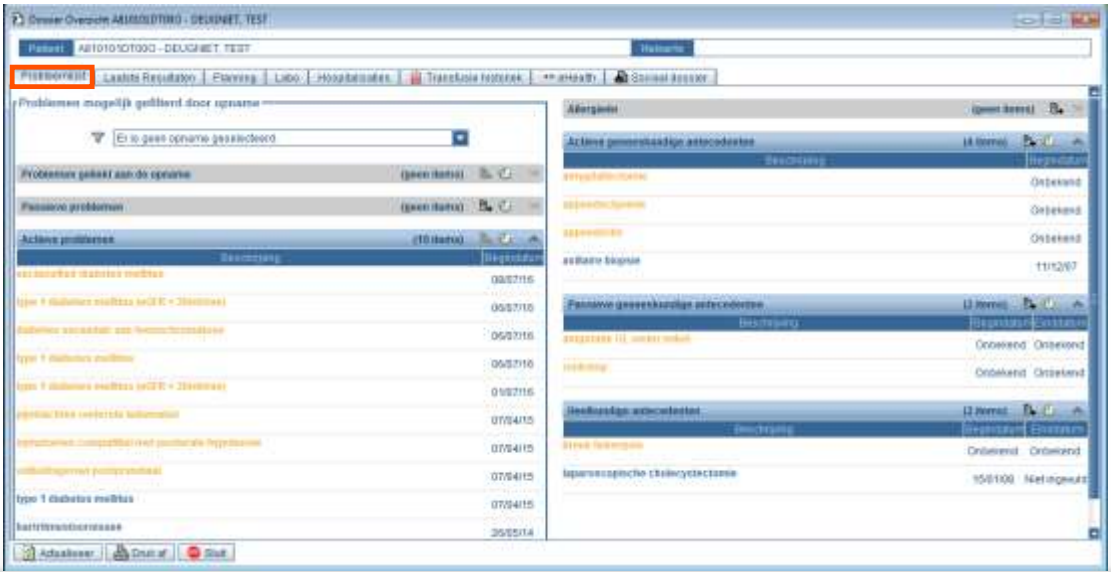

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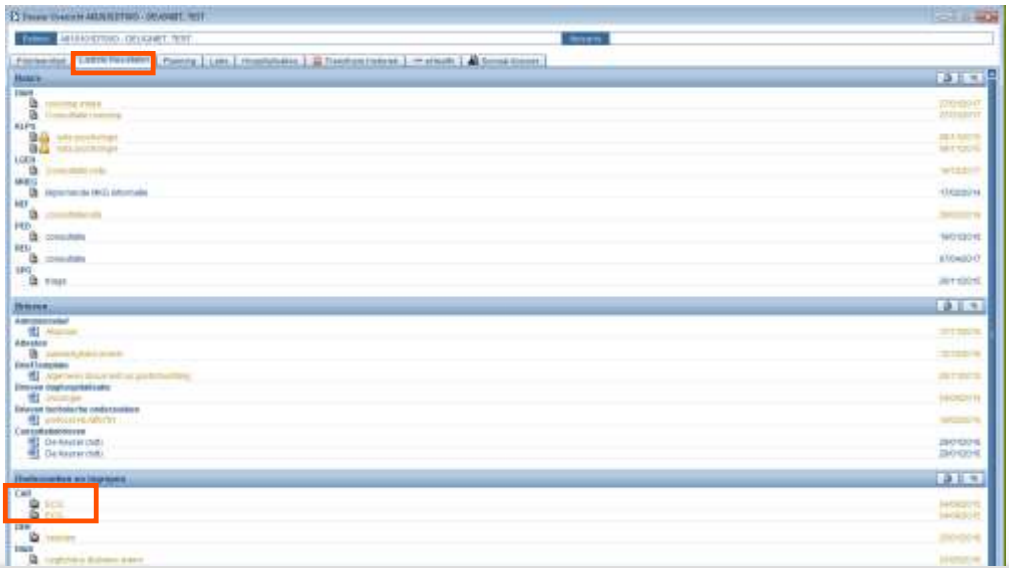

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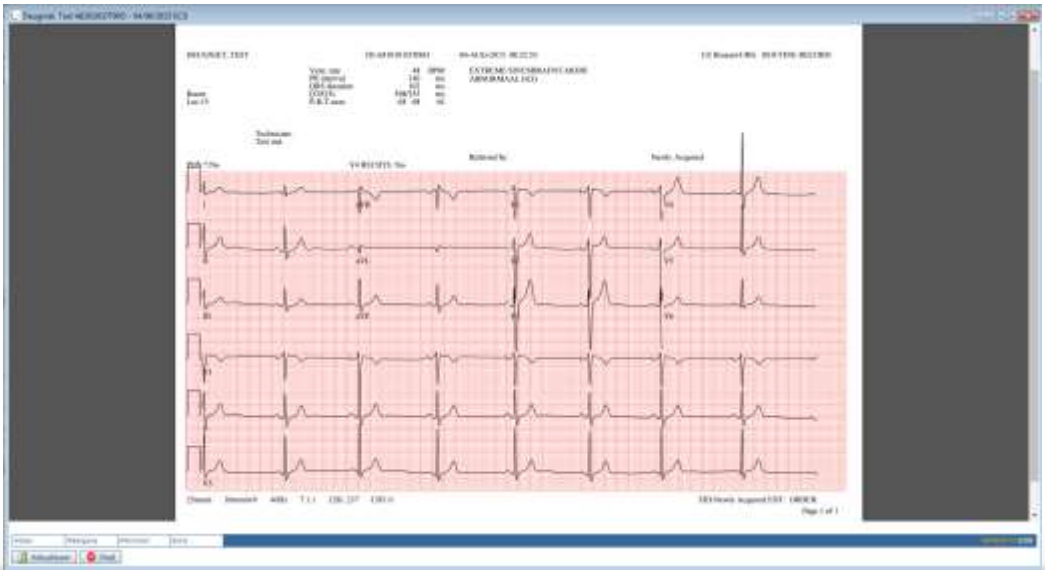

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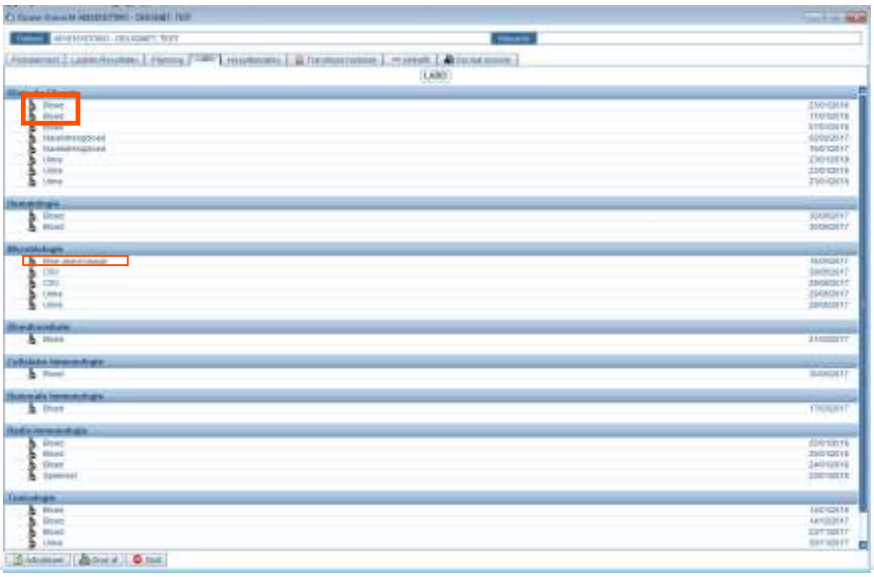

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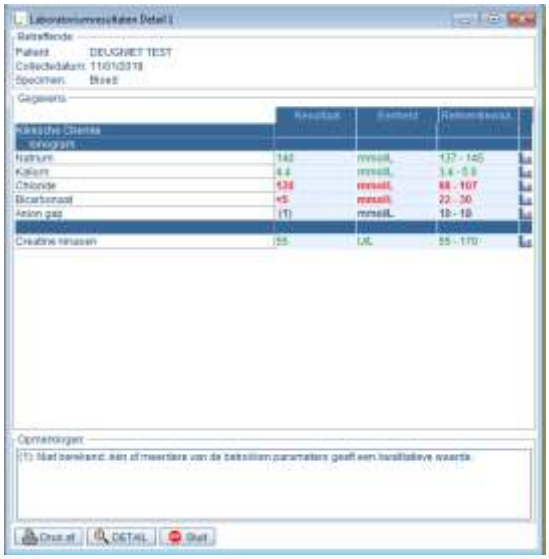

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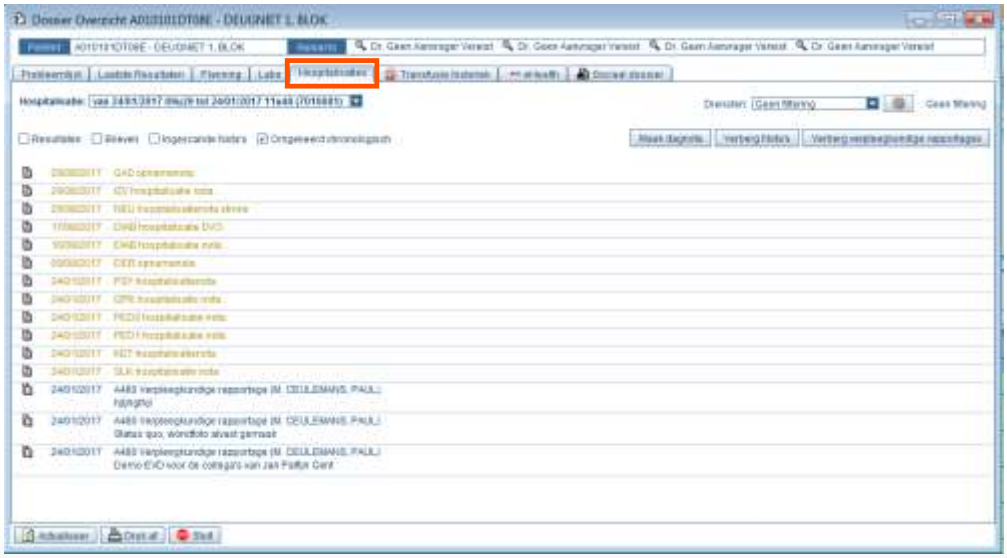

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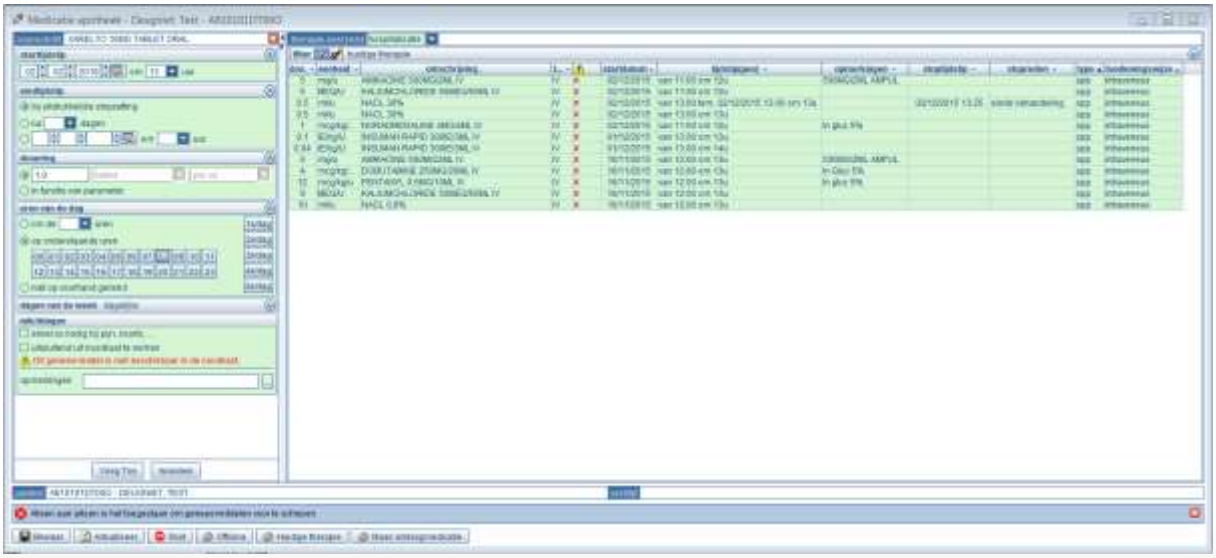

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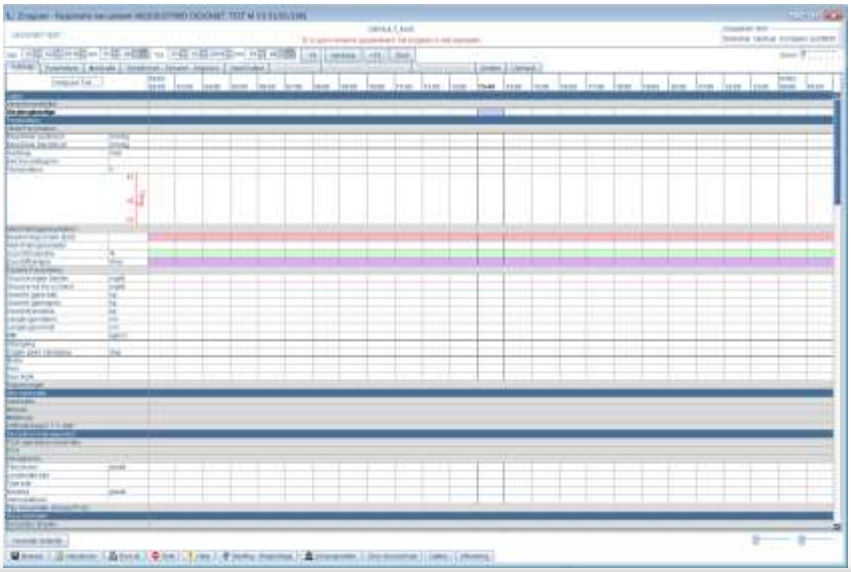

INFORMATION OVERLOAD?

- All information in real-time available for every healthcare provider
- Enormous amount of data
- Difficult for healthcare providers to take all information into account when taking clinical decisions
- Every process requires information
  - Patient data (EMD, lab values, medications, …)
  - Knowledge (guidelines, databases for interactions and contraindications, …)

→ Assist with Clinical decision support (CDS)

WHAT ARE CLINICAL DECISION SUPPORT SYSTEMS?

- 'Computer systems which assist humans (mainly clinicians) in making optimal clinical decisions' (Wright, 2009)
  - ➔ assist, not replace clinical reasoning!
- 'CPOE with CDS key element for safe decision-making and improving patient safety' (IOM)
- Help health care providers to take into account existing knowledge and clinical patient data when making decisions

Bron: http://kathymillersciencewriter.com

WHAT ARE CLINICAL DECISION SUPPORT SYSTEMS?

- Different types based on:
  - moment at which they deliver support / the type of decisions (diagnosis, prescribing, administration, preparation, …)
  - degree of active versus passive support (active = alerts, pop-ups; passive = activation by physician)
  - knowledge-based (using a database derived from the medical literature or guidelines) or non-knowledge-based (using computer learning from past experiences or data patterns)
  - stand alone or integrated in clinical information system

CDS AND ACCREDITATION STANDARDS

- Focus on medication related CDS because of accreditation standards

CDS AND ACCREDITATION STANDARDS

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Intent of MMU.5.1

Good medication management includes two reviews of each prescription or order:

The process to conduct an appropriateness review (the first review) for an order or prescription prior to dispensing includes evaluation by a trained professional of

a) the appropriateness of the drug, dose, frequency, and route of administration;
b) therapeutic duplication;
c) real or potential allergies or sensitivities;
d) real or potential interactions between the medication and other medications or food;
e) variation from hospital criteria for use;
f) patient's weight and other physiological information; and
g) other contraindications.

When computer software programs are used to cross-check drug/drug interactions and drug allergies, the software is current and updated according to recommendations of the software manufacturer.

CDS IN UZ BRUSSEL

Time required for appropriateness review (a ➔ g for all prescriptions):

- Check EMD + information retrieval: suppose 5 min.
- Number of electronic prescriptions on a weekly basis: 6414
- Time required for checking prescriptions:

  6414 x 5 min. = 32070 min. = 534.5 hours per week or almost 76 hours per day

- If a pharmacist does this 8 hours per day ➔ 9.5 fulltime equivalents required

➔ Need for CDS

BENEFITS AND RISKS OF CURRENT CDS

JOURNAL OF MEDICAL INTERNET RESEARCH Légat et al

Review

Clinical Decision Support Systems for Drug Allergy Checking: Systematic Review

Laura Légat[1*], MSc; Sven Van Laere[2*], MSc; Marc Nyssen[2], PhD; Stephane Steurbaut[1], PhD; Alain G Dupont[1], PhD; Pieter Cornu[1], PhD

[1]Research Group Clinical Pharmacology and Clinical Pharmacy, Centre for Pharmaceutical Research, Vrije Universiteit Brussel, Brussels, Belgium
[2]Research Group of Biostatistics and Medical Informatics, Department of Public Health, Vrije Universiteit Brussel, Brussels, Belgium
*these authors contributed equally

J Med Internet Res 2018 | vol. 20 | iss. 9 | e258 | p.1
(page number not for citation purposes)

CDS FOR DRUG ALLERGY CHECKING

- Several key findings were identified:
  - Evidence of the usefulness of clinical decision support for drug allergies
  - Important problems associated with their use:
    - Accurate and structured documenting of information on drug allergies in electronic health records (EHRs) is difficult
    - Underreporting of drug allergies, outdated or inaccurate drug allergy information in EHRs
    - No generally accepted standard terminology for structured documentation of allergy information
    - Consistently reported low specificity of drug allergy alerts ➔ **alert override rates of up to 90%, leading to alert fatigue**

Legat, L., et al. (2018). "Clinical Decision Support Systems for Drug Allergy Checking: Systematic Review." J Med Internet Res **20**(9): e258.

- Important challenges remain for increasing the specificity of drug allergy alerts
- It remains difficult to reduce drug allergy alert overload while maintaining patient safety as the highest priority
- We found only one study specifically reporting outcomes related to CDSS for drug allergies. It showed that adverse drug events resulting from overridden drug allergy alerts do not occur frequently

Legat, L., et al. (2018). "Clinical Decision Support Systems for Drug Allergy Checking: Systematic Review." J Med Internet Res **20**(9): e258.

CDS FOR DRUG DRUG INTERACTION CHECKING

International Journal of Medical Informatics 111 (2018) 165–171

Contents lists available at ScienceDirect

International Journal of Medical Informatics

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

ELSEVIER

High-priority and low-priority drug–drug interactions in different international electronic health record systems: A comparative study

Pieter Cornu[a], Shobha Phansalkar[b,c], Diane L. Seger[b,d], Insook Cho[e], Sarah Pontefract[f], Alexandra Robertson[g], David W. Bates[b,c,h], Sarah P. Slight[b,i,j,e]

Results: Of the 15 previously defined, high-priority, class-based DDIs, alert warnings were found to exist for 11 in both the Korean and UK systems, 9 in the Belgian system, and all 15 in the two US systems. The specific combinations that were included in these class-based DDIs varied considerably in number, type and level of severity amongst systems. Alerts were only active for 8.4% (52/619) and 52.4% (111/212) of the specific drug–drug combinations contained in the Belgian and UK systems, respectively. Hard stops (not possible to override) existed in the US and UK systems only. The override rates for high-priority alerts requiring provider action ranged from 56.7% to 83.3%. Of the 33 previously defined low-priority DDIs, active alerts existed only in the US systems, for three class-based DDIs. The majority were non-interruptive.

Conclusions: Alert warnings existed for most of the high-priority DDIs in the different EHRs but overriding them was easy in most of the systems. In addition to validating the high- and low-priority DDIs, this study reported a lack of standardization in DDI levels across different international knowledge bases.

Cornu, P., et al. (2018). "High-priority and low-priority drug-drug interactions in different international electronic health record systems: A comparative study." Int J Med Inform **111**: 165-171.

ORIGINAL RESEARCH

A Systematic Review of Clinical Decision Support Systems for Clinical Oncology Practice

Pamala A. Pawloski, PharmD[a,b]; Gabriel A. Brooks, MD[c]; Matthew E. Nielsen, MD[d]; and Barbara A. Olson-Bullis, MA[e]

Pawloski, P. A., et al. (2019). "A Systematic Review of Clinical Decision Support Systems for Clinical Oncology Practice." J Natl Compr Canc Netw 17(4): 331-338.

Abstract

Background: Electronic health records are central to cancer care delivery. Electronic clinical decision support (CDS) systems can potentially improve cancer care quality and safety. However, little is known regarding the use of CDS systems in clinical oncology and their impact on patient outcomes. **Methods:** A systematic review of peer-reviewed studies was performed to evaluate clinically relevant outcomes related to the use of CDS tools for the diagnosis, treatment, and supportive care of patients with cancer. Peer-reviewed studies published from 1995 through 2016 were included if they assessed clinical outcomes, patient-reported outcomes (PROs), costs, or care delivery process measures. **Results:** Electronic database searches yielded 2,439 potentially eligible papers, with 24 studies included after final review. Most studies used an uncontrolled, pre-post intervention design. A total of 23 studies reported improvement in key study outcomes with use of oncology CDS systems, and 12 studies assessing the systems for computerized chemotherapy order entry demonstrated reductions in prescribing error rates, medication-related safety events, and workflow interruptions. The remaining studies examined oncology clinical pathways, guideline adherence, systems for collection and communication of PROs, and prescriber alerts. **Conclusions:** There is a paucity of data evaluating clinically relevant outcomes of CDS system implementation in oncology care. Currently available data suggest that these systems can have a positive impact on the quality of cancer care delivery. However, there is a critical need to rigorously evaluate CDS systems in oncology to better understand how they can be implemented to improve patient outcomes.

Pawloski, P. A., et al. (2019). "A Systematic Review of Clinical Decision Support Systems for Clinical Oncology Practice." J Natl Compr Canc Netw 17(4): 331-338.

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

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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[a,*], M.T. Baysari[a,b], J.I. Westbrook[a]

[a] Centre for Health Systems and Safety Research, Australian Institute of Health Innovation, Faculty of Medicine and Health Sciences, Macquarie University, Australia
[b] St Vincent's Clinical School, University of NSW, Australia

Page, N., et al. (2017). "A systematic review of the effectiveness of interruptive medication prescribing alerts in hospital CPOE systems to change prescriber behavior and improve patient safety." Int J Med Inform 105: 22-30.

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Results: Twenty-three studies describing 32 alerts classified into 11 alert categories were identified. The most common alert categories studied were drug-condition interaction (n = 6), drug-drug interaction alerts (n = 6) and corollary order alerts (n = 6). All 23 papers investigated the effect of the intervention alert on at least one outcome measure of prescriber behavior. Just over half of the studies (53%, n = 17) reported a statistically significant beneficial effect from the intervention alert; 34% (n = 11) reported no statistically significant effect, and 6% (n = 2) reported a significant detrimental effect. Two studies also evaluated the effect of alerts on patient outcome measures; neither finding that patient outcomes significantly improved following alert implementation (6%, n = 2).

Discussion and conclusion: The current evidence-base does not show a clear indication that particular categories of alerts are more effective than others. While the majority of alert categories were shown to improve outcomes in some studies, there were also many cases where outcomes did not improve. This lack of evidence hinders decisions about the amount and type of decision support that should be integrated into CPOE systems to increase safety while reducing the risk of alert fatigue. Virtually no studies have sought to investigate the impact on changes to prescriber behavior and outcomes overall when alerts from multiple categories are incorporated within the same system.

Page, N., et al. (2017). "A systematic review of the effectiveness of interruptive medication prescribing alerts in hospital CPOE systems to change prescriber behavior and improve patient safety." Int J Med Inform 105: 22-30.

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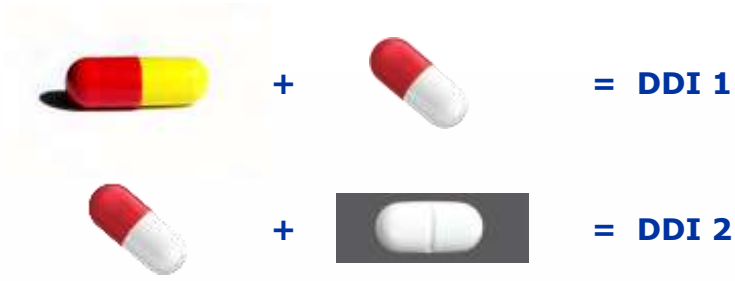
CDS FUTURE CHALLENGES

- Develop CDS systems with adequate specificity ➔ relevant alerts that are useful and not a burden for the healthcare provider
- Context-aware alerting (based on individual patient data)
- From separate CDS modules (DDIs, dosing, CIs) to integrated patient centered support ➔ complex decision rules
- Finding the right balance between over- and under-alerting
- Evaluation of outcome

EXAMPLE OF DRUG DRUG INTERACTION SCREENING

Classical approach:



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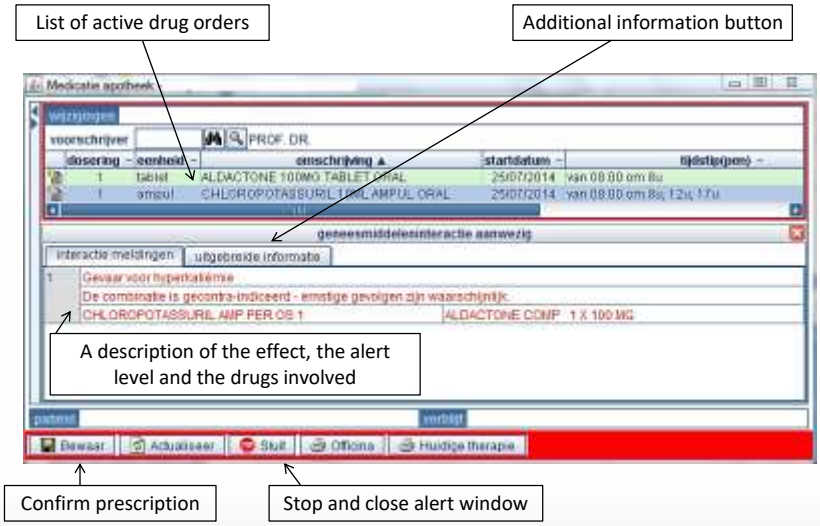
DRUG DRUG INTERACTION SCREENING UZ BRUSSEL

- homegrown hospital information system
- graphical user interface of the CDS is self developed
- DDI screening based on commercial Delphicare® database
- 8 severity levels of DDIs
- DDI screening version 1 implemented in 2009 by IT department, only screening for level 1 and 2 DDIs
- content of Delphicare® database was used without adjustments

DDI ALERT OLD SYSTEM



DDI ALERTS OLD SYSTEM

Intervention class	Potential drug-drug interaction	Number of alerts	Percentage of overridden alerts
1	**risk of hyperkalemia**	2084	**85.7**
	risk of myopathy and renal failure	200	74.5
	risk of bleeding	147	85.7
	premature baby and infants: lung and kidney damage	18	100.0
	increased effect of rifabutin	17	52.9
	reduced efficacy of azoles	7	85.7
	increased effect of pimozide (life-threatening arrhythmias)	3	100.0
	decreased effect of beta-symapthomimetics	3	33.3
	exceptional cases of circulatory disorders and infarction	2	100.0
	antagonistic effect on the bronchi resistance	1	100.0
2	reduced cardio-protective efficacy of clopidogrel	329	64.7
	stronger adverse effects of carbamazepine/may reduce the efficacy of azoles	29	93.1
	development of serotonin syndrome	13	69.2
	increased or decreased effect of bupropion	8	100.0
	reduced or increased efficacy of voriconazole is possible	8	50.0
	increased effect of tizanidine	6	50.0
	reduced effect of opioid agonists	6	66.7
	increased effect of rosuvastatin	4	25.0
	increased effect of lercanidipine (hypotension)	2	100.0
	amantadine intoxication is possible	2	50.0
	increase in nephro-, oto- and neurotoxicity	1	100.0

DDI ALERTS OLD SYSTEM

- 2890 alerts between 1st January 2010 and 30 June 2011
- only screening for level "contra-indicated" (2482 alerts) and "precautionary contraindicated" (408 alerts)
- for 2373 (82,1%) DDI alerts the alert was overridden and the combination was given

- Patient harm?
- With good reason overruled?
- Usefulness of the system?

REASONS OF POOR CDSS PERFORMANCE OLD SYSTEM

Delphicare® designed mainly for community pharmacists:

- often no clear alternatives
- alerts don't take into account patient characteristics
- same screening interval for every DDI
- pharmacist evaluates clinical relevance of DDI

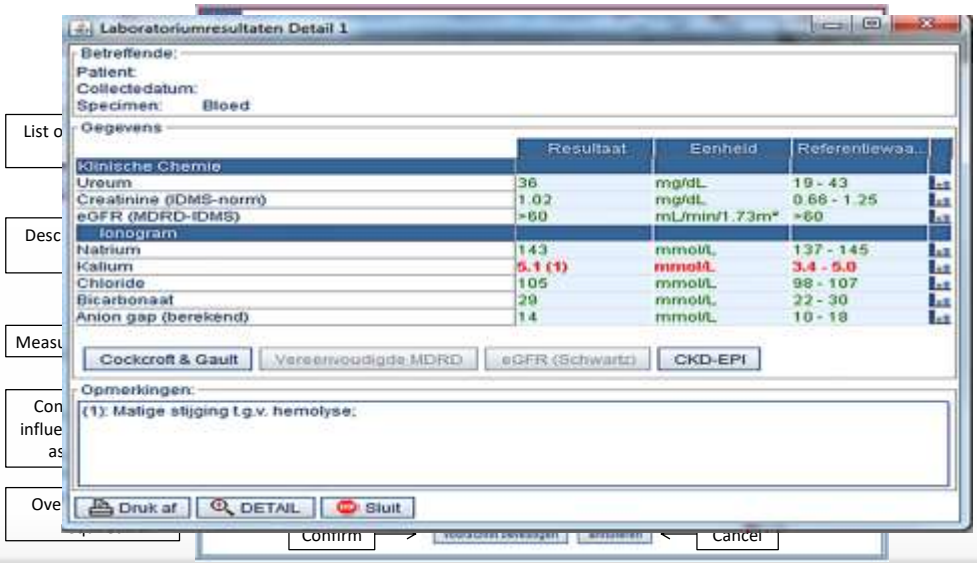
Different situation in the hospital:

- alerts provided to physicians
- only alert when relevant for the individual patient

REDESIGNED THE SYSTEM

- customization of the severity classification in three in-house severity levels
- context driven alerts
- define individual screening intervals
- if possible, provide alternative medication
- real time follow-up of alerts by clinical pharmacist

CONTEXT AWARE: LAB VALUES



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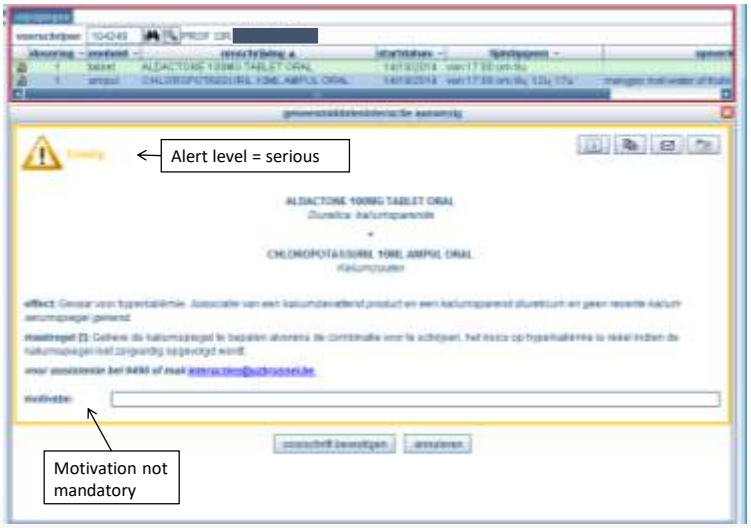
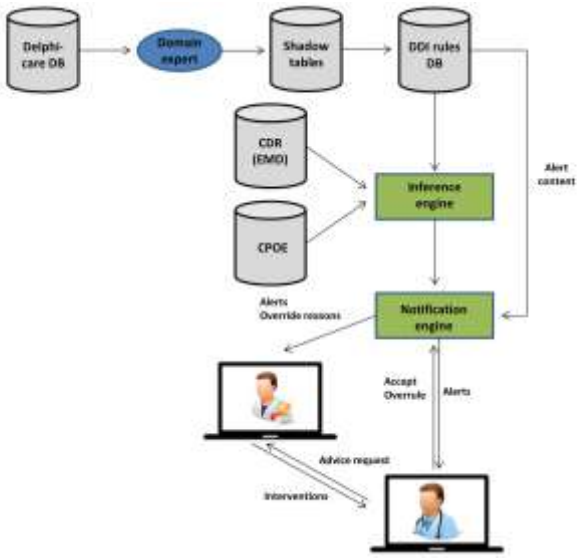


NEW DDI CDSS



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Evaluation of context-specific alerts for potassium-increasing drug-drug interactions: A pre-post study

Katoo M. Muylle [a,*], Kristof Gentens [b], Alain G. Dupont [a], Pieter Cornu [a,b]

[a] Research Group Clinical Pharmacology & Clinical Pharmacy (KFAR), Faculty of Medicine and Pharmacy, Vrije Universiteit Brussel, Brussels, Laarbeeklaan 103, 1090, Brussels, Belgium
[b] Department of Medical Informatics, UZ Brussel, Laarbeeklaan 101, 1090, Brussels, Belgium

Objective:

- Reduced alert burden?
- Improvement of alert acceptance?
- Effect on occurrence of hyperkalemia?

Design:

- Pre-post intervention study
- Pre: all level 1 alerts advising absolute contraindication
- Post: level 1, 2 or 3 based on the patient's recent lab value of potassium
- Alert acceptance:
  - ➔ non-prescription or non-administration for level 1 alerts
  - ➔ monitoring of the potassium levels for level 2 alerts

Results:

	Pre-intervention	Post-intervention (level 1 and level 2)	Statistics
Acceptance = Prescription discontinued (level 1) or monitoring (level 2)	84 (5.7%)	77 (86.5%)	*P* = < 0.001 RR = 15.048 (95% CI 12.037 – 18.811)
Acceptance = DDI not administered (level 1) or monitoring (level 2)	356 (24.4%)	78 (87.6%)	*P* = < 0.001 RR = 3.597 (95% CI 3.192 – 4.053)

Risk of hyperkalemia:

- Crude incidence of hyperkalemia after a DDI alert was triggered

  3.9% pre-intervention period

  5.1% post-intervention period

  (P = 0.200)

- Generalized linear mixed model ➔ effect of the intervention on the occurrence of hyperkalemia not significant (adj. OR 1.091, 95% CI 0.172 -6.919)

Variable	OR	95% CI
Intervention	1.091	0.172 – 6.919
Sex: female vs male	1.005	0.154 – 6.538
Pre-DDI alert potassium	5.703	2.569 – 12.657
BMI	0.915	0.748 – 1.118
Systemic corticosteroids	1.790	0.484 – 6.620
ACE inhibitors	0.611	0.155 – 2.409
eGFR: impaired vs normal	2.476	0.667 – 9.193

Risk of hyperkalemia:

- Only patients with an available post-DDI measurement could be included
- 69.22% of missing outcomes were from patients from the pre-intervention period
- High-risk patients were more likely to have a post-DDI alert measurement

Conclusion:

- Safely reduced the DDI hyperkalemia alert burden with 92.8 % without compromising patient safety ➔ no significant difference in the occurrence of hyperkalemia

CDS FOR DDI SCREENING: FUTURE CHALLENGES

- Evaluation of outcome for other DDIs
- Development of context-aware algorithms for complex DDIs
  - Pharmacoepidemiological approach
  - Build prediction models with large datasets from EPD
  - Prediction model ➔ prediction rule
  - Validate and handle missing data
  - Requires availability of structured (coded) data
  - Machine learning approach?

THANK YOU

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