Legemiddelsløyfer

Notat fra Kunnskapssenteret
Systematisk litteratursøk med sortering
November 2015

kunnskapssenteret

Nasjonalt kunnskapssenter for helsetjenesten
Postboks 7004, St. Olavs plass
N-0130 Oslo
(+47) 23 25 50 00
www.kunnskapssenteret.no
Notat: ISBN 978-82-8121-990-8

November 2015

kunnskapssenteret

Tittel	Legemiddelsløyfer
English title	Closed loop medication
Institusjon	Nasjonalt kunnskapssenter for helsetjenesten
Ansvarlig	Magne Nylenna, direktør
Forfattere	Vist, Gunn Elisabeth, prosjektleder, seksjonsleder, Nasjonalt kunnskapssenter for helsetjenesten Holte, Hilde H, seniorforsker, Nasjonalt kunnskapssenter for helsetjenesten Straumann, Gyri Hval, Forskningsbibliotekar, Nasjonalt kunnskapssenter for helsetjenesten
ISBN	978-82-8121-990-8
Notat	November – 2015
Prosjektnummer	1058
Publikasjonstype	Systematisk litteratursøk med sortering
Antall sider	22 (82 inklusiv vedlegg)
Oppdragsgiver	Helsedirektoratet ved Ida Møller Solheim, Avdeling EIJI – Én innbygger – én journal
Emneord(MeSH)	Closed loop medication, computerized physician order entry,
Sitering	Vist GE, Holte HH, Straumann GH. Legemiddelsløyfer. Notat 2015. Oslo: Nasjonalt kunnskapssenter for helsetjenesten, 2015.

Nasjonalt kunnskapssenter for helsetjenesten
Oslo, november 2015

Hovedfunn

Nasjonalt kunnskapssenter for helsetjenesten fikk i oppdrag av Helsedirektoratet å utføre et systematisk litteratursøk med påfølgende sortering av mulig relevante publikasjoner. Oppdraget var å finne litteratur/forskning om bruk av helt eller delvis lukket legemiddelsløyfe i sykehus eller på institusjon.

Metode

Vi utarbeidet søkestrategi for et systematisk litteratursøk. Det ble søkt i medisinske databaser etter systematiske oversikter og primærstudier. Søket ble utført i oktober 2015. To forskere gikk uavhengig av hverandre gjennom identifiserte publikasjoner/ referanser og vurderte relevans i forhold til inklusjonskriteriene.

Resultater

Søket vårt identifiserte 3280 unike referanser. Vi vurderte at 124 av dem muligens var relevante for spørsmålet om bruk av legemiddelsløyfer i sykehus.

- Vi vurderte 45 oversiktsartikler som relevante, de omhandler:
  - Beslutningsstøtte (10)
  - Elektronisk foreskrivning (11)
  - Elektroniske alarmsystemer (3)
  - Tracking systemer og barcode (4)
  - Flere tiltak for å redusere feil (8)
  - Generelt om helseinformasjonsteknologi (9)

- Vi vurderte 79 primærstudier som relevante, de omhandler:
  - Beslutningsstøtte (20)
  - Elektronisk foreskrivning (29)
  - Elektroniske alarmsystemer (17)
  - Automatisk administrering og barcode (8)
  - Samstemming (3)
  - Lukket legemiddelsløyfe (2)

Tittel:

Legemiddelsløyfer – systematisk litteratursøk med sortert referanseliste

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Publikasjonstype:

Systematisk litteratursøk med sortering

Systematisk litteratursøk med sortering er resultatet av å
- søke etter relevant litteratur ifølge en søkestrategi og
- eventuelt sortere denne litteraturen i grupper presentert med referanser og vanligvis sammendrag

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Svarer ikke på alt:

- Ingen kritisk vurdering av studienes kvalitet
- Ingen analyse eller sammenfatning av studiene
- Ingen anbefalinger

Hvem står bak denne publikasjonen?

Kunnskapssenteret har gjennomført oppdraget etter forespørsel fra Helsedirektoratet

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Når ble litteratursøket utført?

Søk etter studier ble avsluttet oktober 2015.

Key messages

The Norwegian Knowledge Centre for the Health Services was comissioned by the Norwegian Directorate of Health to perform a systematic search for studies evaluating the effect of closed loop medication in hospital or institution.

Methods

We designed and carried out a systematic litterature search in relevant electronic databases for systematic reviews and primary resarch. The search was finalised in October 2015. Two researchers independetly reviewed all references for potential relevance based on our inclusion criteria.

Results

Our serach identified 3280 unique references. We judged that 124 of them are potentially relevant to the question of closed loop medication in hospitals.

- We judged 45 review articles as potentially relevant, we sorted them into the following categories:
  - Decision support and order set (10)
  - Electronic prescribing(11)
  - Electronicc alert systems (3)
  - Tracking systems and barcode (4)
  - Several interventions to reduce errors (8)
  - Generally about health information technology (9)

- We judged 79 primary studies as potentially relevant, we sorted them into the following categories:
  - Decision support, reminders and order set (20)
  - Electronic prescribing (29)
  - Electronic alert systems (17)
  - Automated dispensing and barcode (8)
  - Medication reconsilliation (3)
  - Closed loop medication (2)

Title:

Closed loop medication – Systematic literature search with organised references

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Type of publication:

Systematic reference list

A systematic reference list is the result of a search for relevant literature according to a specific search strategy. The references resulting from the search are then grouped and presented with their abstracts.

Does not answer everything:

- No critical evaluation of study quality
- No analysis or synthesis of the studies
- No recommendations

Publisher:

Norwegian Knowledge Centre for the Health Services

Updated:

Last search for studies: October 2015.

Innhold

Forord

Nasjonalt kunnskapssenter for helsetjenesten fikk i oppdrag fra Ida Møller Solheim ved Avdeling EIJI – Én innbygger – én journal i Helsedirektoratet å finne litteratur om effekter av bruk av helt eller delvis lukket legemiddelsløyfe ved hjelp av IKT. Litteraturen i vår referanseliste kan utgjøre et relevant dokumentasjonsgrunnlag for beslutninger av helsemyndigheter i valg av fremtidig løsningskonsepter.

Prosjektgruppen har bestått av:

- Gunn Elisabeth Vist, seksjonsleder og seniorforsker, Kunnskapssenteret
- Hilde H Holte, seniorforsker, Kunnskapssenteret
- Gyri Hval Straumann, forskningsbibliotekar, Kunnskapssenteret

Gro Jamtvedt	Gunn E Vist
Avdelingsdirektør	*Seksjonsleder og prosjektleder*

Innledning

Nasjonalt kunnskapssenter for helsetjenesten fikk i oppdrag fra Helsedirektoratet å finne litteratur om effekter av bruk av helt eller delvis lukket legemiddelsløyfe ved hjelp av Informasjons og Kommunikasjons-Teknologi (IKT) i sykehus eller på institusjon.

En legemiddelsløyfe omhandler prosessen fra legen begynner å skrive ut et legemiddel via leveranse, klargjøring og administrasjon av legemiddelet og helt frem til evaluering. Dette brukes primært for legemiddelhåndtering i sykehus. En lukket legemiddelsløyfe omfatter metoder for sikring av legemiddelsløyfen slik at riktig person får riktig legemiddel til rett tid, i riktig dose og administrert på rett måte ved å ta i bruk nye teknologiske hjelpemidler, det inkluderer også sikring av riktig evaluering av effekt og sikkerhet.

Hensikten med legemiddelsløyfer er å redusere legemiddelfeil og øke pasientsikkerheten.

Styrker og svakheter ved litteratursøk med sortering

Ved litteratursøk gjennomfører vi systematiske litteratursøk for en gitt problemstilling. Resultatene fra søket blir i sin helhet overlevert oppdragsgiver, eller vi kan gjennomgå søkeresultatet før overleveringen og sortere ut ikke-relevante artikler. Dette gjøres basert på tittel og eventuelt sammendrag. Artiklene innhentes ikke i fulltekst. Det gjør at vi kan ha inkludert titler som ville vist seg ikke å være relevante ved gjennomlesning av fulltekst. Vi benytter kun databaser for identifisering av litteratur og kan derfor ha gått glipp av potensielt relevante studier. Andre måter å identifisere studier på, som søk i referanselister, kontakt med eksperter på fagfeltet og upublisert litteratur, er ikke utført i dette oppdraget. Vi gjennomfører ingen kvalitetsvurdering av artiklene.

Ved en full forskningsoppsummering ville vi ha innhentet artiklene i fulltekst for endelig vurdering opp mot inklusjonskritene. Inkluderte studier ville så blitt kvalitetsvurdert i henhold til våre sjekklister og resultater sammenstilt og diskutert.

Begrunnelse for valg av søkestrategi

Vi har søkt i elektroniske kilder, men ikke etter grå litteratur eller liknende. Søket er ikke avgrenset med tanke på språk. Søket for systematiske oversikter er avgrenset til siste fem år, mens søket for primærstudier ikke er avgrenset med tanke på år.

I søkene er det lagt på filter for å begrense til kontrollerte studier.

Metode

Litteratursøking

Vi søkte systematisk etter litteratur i følgende databaser:

- Embase
- Ovid MEDLINE
- Cochrane Library
  - Cochrane Database of Systematic Reviews (CDSR)
  - Database of Abstracts of Reviews of Effects (DARE)
  - Cochrane Central Register of Controlled Trials (CENTRAL)
- Centre for Reviews and Dissemination (CRD)

Forskningsbibliotekar Gyri Hval Straumann planla og utførte samtlige søk. En annen forskningsbibliotekar, Elisabet Hafstad, kvalitetssikret søkestrategien. Den fullstendige søkestrategien er vist i vedlegg 1. Søk etter studier ble avsluttet oktober 2015.

Vi la bestillingen til grunn ved utarbeiding av litteratursøket og søkte etter artikler som oppfylte våre inklusjonskriterier for populasjon og intervensjon. I søkene er det lagt på filter for å begrense til kontrollerte studier.

Inklusjonskriterier

Populasjon:	Helsepersonell, enheter (avdelinger) eller institusjoner som behandler pasienter som er innlagt i sykehus eller på institusjon og som bruker legemidler
Tiltak:	Helt eller delvis lukket legemiddelsløyfe ved hjelp av IKT
Sammenlikning:	Ikke lukket legemiddelsløyfe, slik som manuelle og papirbaserte løsninger for legemiddelhåndtering
Utfall:	Ikke presisert da de ikke vurderes i søk og sorter
Studiedesign	Systematiske oversikter publisert i 201 eller senere, randomiserte kontrollerte studier, alle typer kontrollerte studier,

	og tidsserieanalyser med flere enn tre målinger før- og tre etter innføring av tiltaket.
Språk:	Ingen begrensninger

Artikkelutvelging

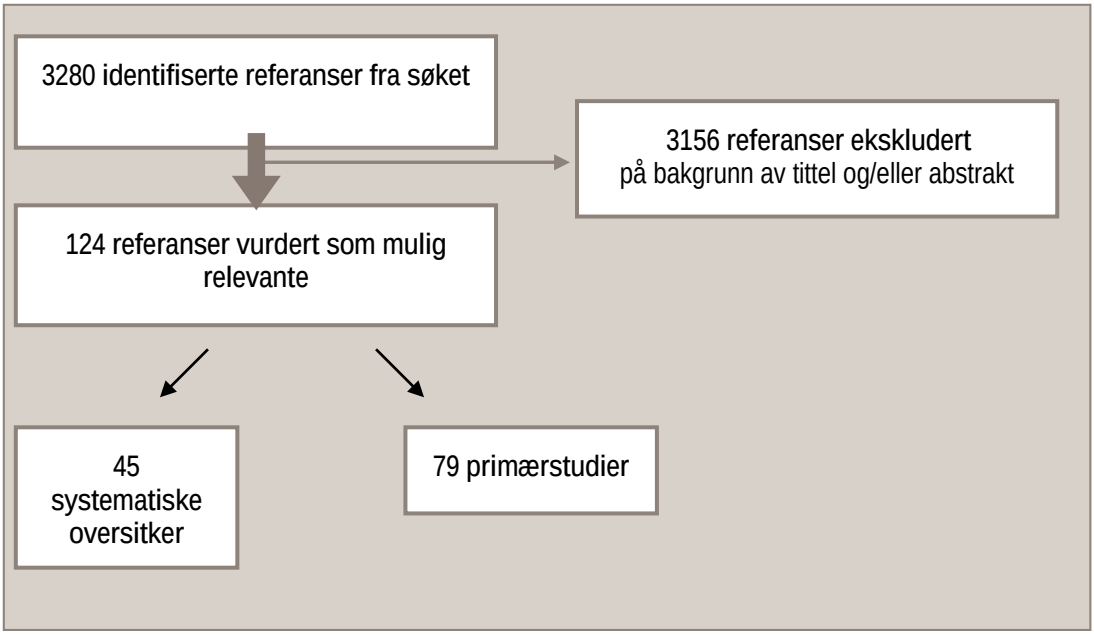
To forskere (GEV og HHH) gikk gjennom alle titler og sammendrag for å vurdere relevans i henhold til inklusjonskriteriene. Vurderingene gjorde de uavhengig av hverandre og sammenlignet i etterkant. Der det var uenighet om vurderingene, ble inklusjon eller eksklusjon avgjort ved konsensus.

Utvelging av litteratur ble kun gjort basert på tittel og sammendrag. Vi bestilte ikke fulltekst av artiklene.

Resultat

Resultat av søk

Søket resulterte i 3280 unike referanser. Vi vurderte 124 av de identifiserte referansene til å være mulig relevante i henhold til inklusjonskriteriene, og har sortert disse.



Figur 1. Flytskjema over identifisert litteratur

Resultat av sorteringen

De mulig relevante referansene ble først sortert i gruppe til systematiske oversikter og primærstudier. Videre ble referansene i begge gruppene kategorisert ut fra intervensjon. De systematiske oversiktene er så presentert etter publikasjonsår der den nyeste presenteres først, se tabell 1, referanse er listet under tabellen. Primærstudiene er videre sortert etter studiedesign der randomiserte studier presenteres før observasjonsstudier, se tabell 2, referansene er listet under tabellen. I vedlegg 2 presenterer vi referansene til de systematiske oversiktene med abstraktet der det var tilgjengelig fordelt i kategoriene som beskrevet. I vedlegg 3 presenterer vi referansene

til primærstudiene med abstraktet der det var tilgjengelig fordelt i kategoriene som beskrevet. Vi oppgir forfattere, tittel på publikasjonen, publikasjonssted og sammendrag av artikkelen slik de fremkom i de elektroniske databasene.

Sortering av oversiktsartiklene

Tabell 1: *Antall oversiktsartikler sortert etter intervensjon*

Tiltak	Antall referanser
Beslutningsstøtte (decision support & order set)	10
Elektronisk foreskrivning	11
Elektroniske alarmsystemer (alerts)	3
Tracking systems & Barcode	4
Flere tiltak for å redusere feil	8
Generelt om helseinformasjonsteknologi	9

Her følger liste av referansene, de er presentert etter sorteringskategoriene, og så med den nyeste først. Referansene er også listet med abstrakt i vedlegg 2.

Beslutningsstøtte (decision support & order sets)

Al-Bahar F, Marriott J, Curtis C, Dhillon H. The effects of computer-aided clinical decision support systems on antibiotic prescribing in secondary care: A systematic review. Int J Pharm Pract 2015;23:24.

Brown CL, Slight SP, Husband AK, Watson NW, Bates DW. A narrative review of medication-related clinical decision support. J Gen Intern Med 2015;30:S86-S87.

Ranji SR, Rennke S, Wachter RM. Computerised provider order entry combined with clinical decision support systems to improve medication safety: a narrative review. BMJ quality & safety 2014;23(9):773-780.

Gillaizeau F, Chan E, Trinquart L, Colombet I, Walton RT, Rege-Walther M, et al. Computerized advice on drug dosage to improve prescribing practice. The Cochrane database of systematic reviews 2013;11:CD002894.

Adams P, Riggio JM, Thomson L, Brandell-Marino R, Merli G. Clinical decision support systems to improve utilization of thromboprophylaxis: a review of the literature and experience with implementation of a computerized physician order entry program. Hospital practice (1995) 2012;40(3):27-39.

Chan AJ, Chan J, Cafazzo JA, Rossos PG, Tripp T, Shojania K, et al. Order sets in health care: a systematic review of their effects. Int J Technol Assess Health Care 2012;28(3):235-240.

Nirantharakumar K, Chen YF, Marshall T, Webber J, Coleman JJ. Clinical decision support systems in the care of inpatients with diabetes in non-critical care setting: systematic review. Diabetic medicine : a journal of the British Diabetic Association 2012;29(6):698-708.

Stultz JS, Nahata MC. Computerized clinical decision support for medication prescribing and utilization in pediatrics. Journal of the American Medical Informatics Association : JAMIA 2012;19(6):942-953.

Jaspers MWM, Smeulers M, Vermeulen H, Peute LW. Effects of clinical decision-support systems on practitioner performance and patient outcomes: a synthesis of high-quality systematic review findings. Journal of the American Medical Informatics Association : JAMIA 2011;18(3):327-334.

Robertson J, Walkom E, Pearson S-A, Hains I, Williamsone M, Newby D. The impact of pharmacy computerised clinical decision support on prescribing, clinical and patient outcomes: a systematic review of the literature. The International journal of pharmacy practice 2010;18(2):69-87.

Elektronisk foreskrivning

Alshahrani F, Marriott J, Cox A. The impact of electronic prescribing systems on the incidence of prescribing errors within in-patients settings: A systematic review. Int J Pharm Pract 2015;23:26-27.

Iankowitz N, Dowden M, Palomino S, Uzokwe H, Worral P. The effectiveness of computer system tools on potentially inappropriate medications ordered at discharge for adults older than 65 years of age: A systematic review. JBI Library of Systematic Reviews 2015;10(13):798-831.

Kukreti V, Cosby R, Cheung A, Lankshear S, Group STCPOEGD. Computerized prescriber order entry in the outpatient oncology setting: from evidence to meaningful use. Curr Oncol 2014;21(4):e604-612.

Nuckols TK, Smith-Spangler C, Morton SC, Asch SM, Patel VM, Anderson LJ, et al. The effectiveness of computerized order entry at reducing preventable adverse drug events and medication errors in hospital settings: a systematic review and meta-analysis. Systematic reviews 2014;3:56.

Porterfield A, Engelbert K, Coustasse A. Electronic prescribing: improving the efficiency and accuracy of prescribing in the ambulatory care setting. Perspectives in health information management / AHIMA, American Health Information Management Association 2014;11:1g.

Georgiou A, Prgomet M, Paoloni R, Creswick N, Hordern A, Walter S, et al. The effect of computerized provider order entry systems on clinical care and work processes in emergency departments: a systematic review of the quantitative literature. Ann Emerg Med 2013;61(6):644-653.e616.

Hermanowski TR, Kowalczyk M, Szafraniec-Burylo SI, Krancberg AN, Pashos CL. Current status and evidence of effects of e-prescribing implementation in United Kingdom, Italy, Germany, Denmark, Poland and United States. Value Health 2013;16 (7):A462-A463.

Poon C, Sabbah D, Wallace C, Duffett M. The effect of prescriber order entry on antibiotic turn-around time: A meta-analysis. Can J Hosp Pharm 2013;66 (4):270.

Radley DC, Wasserman MR, Olsho LE, Shoemaker SJ, Spranca MD, Bradshaw B. Reduction in medication errors in hospitals due to adoption of computerized provider order entry systems. Journal of the American Medical Informatics Association : JAMIA 2013;20(3):470-476.

Georgiou A, Prgomet M, Markewycz A, Adams E, Westbrook JI. The impact of computerized provider order entry systems on medical-imaging services: a systematic review. Journal of the American Medical Informatics Association : JAMIA 2011;18(3):335-340.

Khajouei R, Jaspers MWM. The impact of CPOE medication systems' design aspects on usability, workflow and medication orders: a systematic review. Methods Inf Med 2010;49(1):3-19.

Elektroniske alarmsystemer

Bayoumi I, Al Balas M, Handler SM, Dolovich L, Hutchison B, Holbrook A. The effectiveness of computerized drug-lab alerts: a systematic review and meta-analysis. Int J Med Inform 2014;83(6):406-415.

Ojeleye O, Avery A, Gupta V, Boyd M. The evidence for the effectiveness of safety alerts in electronic patient medication record systems at the point of pharmacy order entry: a systematic review. BMC Med Inform Decis Mak 2013; 13: 69.

Forster AJ, Jennings A, Chow C, Leeder C, van Walraven C. A systematic review to evaluate the accuracy of electronic adverse drug event detection. Journal of the American Medical Informatics Association: JAMIA 2012; 19(1): 31-38.

Tracking systems and barcode

Dobson I, Doan Q, Hung G. A systematic review of patient tracking systems for use in the pediatric emergency department. The Journal of emergency medicine 2013; 44(1): 242-248.

Kullberg A, Larsen J, Sharp L. 'Why is there another person's name on my infusion bag?' Patient safety in chemotherapy care - a review of the literature. European journal of oncology nursing : the official journal of European Oncology Nursing Society 2013;17(2):228-235.

Voshall B, Piscotty R, Lawrence J, Targosz M. Barcode medication administration work-arounds: a systematic review and implications for nurse executives. The Journal of nursing administration 2013;43(10):530-535.

Snyder SR, Favoretto AM, Derzon JH, Christenson RH, Kahn SE, Shaw CS, et al. Effectiveness of barcoding for reducing patient specimen and laboratory testing identification errors: A Laboratory Medicine Best Practices systematic review and meta-analysis. Clin Biochem 2012;45(13-14):988-998.

Flere tiltak for å redusere feil

Maaskant JM, Vermeulen H, Apampa B, Fernando B, Ghaleb MA, Neubert A, et al. Interventions for reducing medication errors in children in hospital. The Cochrane database of systematic reviews 2015;3:CD006208.

Acheampong F, Anto BP, Koffuor GA. Medication safety strategies in hospitals--a systematic review. The International journal of risk & safety in medicine 2014; 26(3): 117-131.

Maaskant J, Vermeulen H, Apampa B, Fernando B, Ghaleb M, Neubert A, et al. Interventions for reducing medication errors in children in hospital: A systematic review. Arch Dis Child2014. p. A156.

Manias E, Kinney S, Cranswick N, Williams A, Borrott N. Interventions to reduce medication errors in pediatric intensive care. The Annals of pharmacotherapy 2014; 48(10):1313-1331.

Rinke ML, Bundy DG, Velasquez CA, Rao S, Zerhouni Y, Lobner K, et al. Interventions to reduce pediatric medication errors: a systematic review. Pediatrics 2014; 134(2):338-360.

Carling CLL, Kirkehei I, Dalsbo TK, Paulsen E. Risks to patient safety associated with implementation of electronic applications for medication management in ambulatory care--a systematic review. BMC Med Inform Decis Mak 2013;13:133.

Clyne B, Bradley MC, Hughes C, Fahey T, Lapane KL. Electronic prescribing and other forms of technology to reduce inappropriate medication use and polypharmacy in older people: a review of current evidence. Clin Geriatr Med 2012; 28(2): 301-322.

Manias E, Williams A, Liew D. Interventions to reduce medication errors in adult intensive care: a systematic review. Br J Clin Pharmacol 2012;74(3):411-423.

Generelt om helseinformasjonsteknologi

Cheung A, Van Velden FHP, Lagerburg V, Minderman N. The organizational and clinical impact of integrating bedside equipment to an information system: A systematic literature review of patient data management systems (PDMS). Int J Med Inform 2015;84(3):155-165.

Jones SS, Rudin RS, Perry T, Shekelle PG. Health information technology: an updated systematic review with a focus on meaningful use. Ann Intern Med 2014; 160(1):48-54.

Minshall S. A review of healthcare information system usability & safety. Stud Health Technol Inform 2013;183:151-156.

McKibbon KA, Lokker C, Handler SM, Dolovich LR, Holbrook AM, O'Reilly D, et al. The effectiveness of integrated health information technologies across the phases of medication management: a systematic review of randomized controlled trials. Journal of the American Medical Informatics Association : JAMIA 2012;19(1):22-30.

Rahadhan P, Poon SK, Land L. Understanding unintended consequences for EMR: a literature review. Stud Health Technol Inform 2012;178:192-198.

Black AD, Car J, Pagliari C, Anandan C, Cresswell K, Bokun T, et al. The impact of eHealth on the quality and safety of health care: a systematic overview. PLoS Med 2011;8(1):e1000387.

McKibbon KA, Lokker C, Handler SM, Dolovich LR, Holbrook AM, O'Reilly D, et al. Enabling medication management through health information technology (Health IT). Evidence report/technology assessment 2011 (201):1-951.

Wulff K, Cummings GG, Marck P, Yurtseven O. Medication administration technologies and patient safety: a mixed-method systematic review. J Adv Nurs 2011; 67(10): 2080-2095.

Fischer SH, Tjia J, Field TS. Impact of health information technology interventions to improve medication laboratory monitoring for ambulatory patients: a systematic review. Journal of the American Medical Informatics Association : JAMIA 2010; 17(6): 631-636.

Sortering av primærstudiene

Tabell 2: *Antall primærstudier sortert etter intervensjon*

Tiltak	Antall referanser
Beslutningsstøtte (decision support, reminders & order set)	20
Elektronisk foreskrivning	29
Elektroniske alarmsystemer (alerts)	17
Automated dispensing systems & Barcode	8
Samstemming (medication reconsiliation)	3
Lukket legemiddelsløyfe (closed loop for anaestesia)	2

Her følger liste av referansene, de er presentert etter sorteringskategoriene, og så med de randomiserte kontrollerte studiene (RCT) først, deretter ikke-randomiserte kontrollerte forsøk (CT), etterfulgt av tidsserieanalyser (ITS) og til sist observasjonsstudiene i alfabetisk rekkefølge. Referansene er også listet med abstrakt i vedlegg 3.

Beslutningsstøtte (decision support, reminders & order set)

RCT

Beeler PE, Eschmann E, Schumacher A, Studt JD, Amann-Vesti B, Blaser J. Impact of electronic reminders on venous thromboprophylaxis after admissions and transfers. Journal of the American Medical Informatics Association : JAMIA 2014; 21(e2): e297-303.

Dexter PR, Perkins S, Overhage JM, Maharry K, Kohler RB, McDonald CJ. A computerized reminder system to increase the use of preventive care for hospitalized patients. The New England journal of medicine 2001;345(13):965-970.

Field TS, Rochon P, Lee M, Gavendo L, Baril JL, Gurwitz JH. Computerized clinical decision support during medication ordering for long-term care residents with renal insufficiency. Journal of the American Medical Informatics Association : JAMIA 2009; 16(4):480-485.

Gurwitz JH, Field TS, Rochon P, Judge J, Harrold LR, Bell CM, et al. Effect of computerized provider order entry with clinical decision support on adverse drug events in the long-term care setting. J Am Geriatr Soc 2008;56(12):2225-2233.

Murray MD, Loos B, Tu W, Eckert GJ, Zhou XH, Tierney WM. Work patterns of ambulatory care pharmacists with access to electronic guideline-based treatment suggestions. American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists 1999;56(3):225-232.

Schnipper JL, Liang CL, Ndumele CD, Pendergrass ML. Effects of a computerized order set on the inpatient management of hyperglycemia: a cluster-randomized controlled trial. Endocrine practice : official journal of the American College of Endocrinology and the American Association of Clinical Endocrinologists 2010;16(2):209-218.

Terrell KM, Perkins AJ, Dexter PR, Hui SL, Callahan CM, Miller DK. Computerized decision support to reduce potentially inappropriate prescribing to older emergency department patients: a randomized, controlled trial. J Am Geriatr Soc 2009; 57(8): 1388-1394.

Terrell KM, Perkins AJ, Hui SL, Callahan CM, Dexter PR, Miller DK. Computerized decision support for medication dosing in renal insufficiency: a randomized, controlled trial. Ann Emerg Med 2010;56(6):623-629.

ITS
Elsaid K, Truong T, Monckeberg M, McCarthy H, Butera J, Collins C. Impact of electronic chemotherapy order forms on prescribing errors at an urban medical center: results from an interrupted time-series analysis. International journal for quality in health care: journal of the International Society for Quality in Health Care / ISQua 2013;25(6):656-663.

Haynes K, Linkin DR, Fishman NO, Bilker WB, Strom BL, Pifer EA, et al. Effectiveness of an information technology intervention to improve prophylactic antibacterial use in the postoperative period. Journal of the American Medical Informatics Association : JAMIA 2011;18(2):164-168.

Wong BW, Mamdani MM, Yu CHY. Impact of computerized insulin order sets on inpatient glycemic control & processes of care: An interrupted time-series study. Canadian Journal of Diabetes 2013;37:S13-S14.

Observasjonsstudier
Ballesca MA, LaGuardia JC, Lee PC, Hwang AM, Park DK, Gardner MN, et al. An electronic order set for acute myocardial infarction is associated with improved patient outcomes through better adherence to clinical practice guidelines. Journal of hospital medicine: an official publication of the Society of Hospital Medicine 2014; 9(3):155-161.

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Elektronisk foreskrivning

RCT

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Elektroniske alarmsystemer (alerts)

RCT

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Controlled trial
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ITS
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Observasjonsstudier
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Automated dispensing systems & Barcode

RCT

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Observasjonsstudier

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Samstemming (medication reconsiliation)

RCT
Schnipper JL, Gandhi TK, Wald JS, Grant RW, Poon EG, Volk LA, et al. Effects of an online personal health record on medication accuracy and safety: a cluster-randomized trial. Journal of the American Medical Informatics Association : JAMIA 2012; 19(5): 728-734.

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Observasjonsstudier
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Lukket legemiddelsløyfe (closed loop for anaestesia)

RCT
Biswas I, Mathew PJ, Singh RS, Puri GD. Evaluation of closed-loop anesthesia delivery for propofol anesthesia in pediatric cardiac surgery. Paediatr Anaesth 2013. p. 1145-1152.

Hemmerling TM, Arbeid E, Wehbe M, Cyr S, Taddei R, Zaouter C. Evaluation of a novel closed-loop total intravenous anaesthesia drug delivery system: a randomized controlled trial. Br J Anaesth 2013;110(6):1031-1039.

Vedlegg 1 Søkestrategier

Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily, Ovid MEDLINE(R) and Ovid OLDMEDLINE(R) 1946 to Present
Dato for søk: 01.10.15

#	Searches	Results
1	Clinical Pharmacy Information Systems/	1130
2	Medical Order Entry Systems/	1718
3	Medication Systems, Hospital/	3281
4	Medication Systems/	766
5	Electronic Prescribing/	663
6	patient identification systems/	1935
7	(closed loop adj5 (medic* or drug* or pharmac* or prescrib* or prescrip*)).ti,ab.	90
8	electronic medication administration record.ti,ab.	38
9	emar.ti,ab.	40
10	(computer* adj2 order entry system*).ti,ab.	383
11	cpoe.ti,ab.	901
12	or/1-11	9071
13	systematic review.kw.	2705
14	meta-analysis.mp,pt.	97946
15	review.pt.	2052409
16	((systematic* or literature) adj3 (overview or review*)).ti,ab.	265271
17	or/13-16	2203750
18	clinical trial.mp.	618698
19	clinical trial.pt.	505436
20	random:.mp.	1002794
21	randomized controlled trial.pt.	411821
22	controlled clinical trial.pt.	91696
23	multicenter study.pt.	196192
24	pragmatic clinical trial.pt.	209
25	(pre-post or "pre test$" or pretest$ or posttest$ or "post test$" or (pre adj5 post)).ti,ab.	76187
26	("quasi-experiment$" or quasiexperiment$ or "quasi random$" or quasirandom$ or "quasi control$" or quasicontrol$ or ((quasi$ or experimental) adj3 (method$ or study or trial or design$ or controlled))).ti,ab,hw.	115311
27	("time series" or "time points").ti,ab,hw.	73523
28	(effect or impact or trial or intervention).ti.	1076152
29	repeated measure*.ti,ab.	30734

30	((before adj5 after) or control group*).ti,ab.	589524
31	(pretest-posttest study or pretesting or pre-post tests or quasi experimental design or quasi experimental study or quasi experimental study design or repeated measurement or repeated measurements or repeated measures or time series).kw.	298
32	or/18-31	2841862
33	12 and 17	547
34	12 and 32	1228
35	limit 33 to yr=»2010-Current»	195
36	34 or 35	1383

Database: Embase 1974 to 2015 October 09
Dato for søk: 12.10.15

#	Searches	Results
1	*medical information system/	6228
2	*hospital information system/	12829
3	*electronic prescribing/	628
4	*patient identification/	631
5	(closed loop adj5 (medic* or drug* or pharmac* or prescrib* or prescrip*)).ti,ab.	132
6	electronic medication administration record.ti,ab.	48
7	emar.ti,ab.	56
8	(computer* adj2 order entry system*).ti,ab.	504
9	cpoe.ti,ab.	1191
10	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9	21394
11	((systematic* or literature) adj3 (overview or review* or search*)).ti,ab.	351499
12	meta-analys*.ti,ab.	103577
13	systematic review/	96447
14	meta analysis/	100152
15	11 or 12 or 13 or 14	457454
16	10 and 15	392
17	clinical trial/	855807
18	randomized controlled trial/	388043
19	exp randomization/	68370
20	randomized.ti,ab.	485756
21	randomised.ti,ab.	97190
22	randomly.ti,ab.	305963
23	trial.ti,ab.	552058
24	controlled study/	4751827
25	time series analysis/	15998
26	pretest posttest design/	888
27	evaluation/	170390
28	intervention study/	25821
29	comparative study/	693484
30	experimental study/	17273

31	time series.ti,ab.	21379
32	(((pre adj test) or pretest) and ((post adj test) or posttest)).ti,ab.	9346
33	time point*.ti,ab.	110489
34	repeated measur*.ti,ab.	40928
35	effect.ti,ab.	3020708
36	impact.ti,ab.	806495
37	or/17-36	8708386
38	10 and 37	3791
39	limit 16 to yr="2010 -Current"	229
40	38 or 39	3919
41	limit 40 to embase	2162

Database: Cochrane Library (Central, HTA, DARE, CDSR)
Dato for søk: 12.10.15

#1	MeSH descriptor: [Clinical Pharmacy Information Systems] this term only	28
#2	MeSH descriptor: [Medical Order Entry Systems] this term only	69
#3	MeSH descriptor: [Medication Systems, Hospital] this term only	49
#4	MeSH descriptor: [Medication Systems] this term only	27
#5	MeSH descriptor: [Electronic Prescribing] this term only	25
#6	MeSH descriptor: [Patient Identification Systems] this term only	15
#7	(closed loop near/5 (medic* or drug* or pharmac* or prescrib* or pre-scrip*)):ti,ab,kw	13
#8	electronic next medication next administration next record*:ti,ab,kw	2
#9	emar:ti,ab,kw	1
#10	(computer* near/2 order entry system*):ti,ab,kw	66
#11	cpoe:ti,ab,kw	21
#12	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 Publication Year from 2010 to 2015, in Cochrane Reviews (Reviews and Protocols)	2
#13	(closed loop near/5 (medic* or drug* or pharmac* or prescrib* or prescrip*))	19
#14	electronic next medication next administration next record*	4
#15	emar	3
#16	(computer* near/2 order entry system*)	94
#17	cpoe	34
#18	#1 or #2 or #3 or #4 or #5 or #6 or #13 or #14 or #15 or #16 or #17 in Trials	169
#19	#12 or #18	171

Database: Centre for Reviews and Dissemination (HTA, DARE)
Dato for søk: 12.10.15

Line	Search	Hits
1	MeSH DESCRIPTOR Clinical Pharmacy Information Systems	7
2	MeSH DESCRIPTOR Medical Order Entry Systems	28
3	MeSH DESCRIPTOR Medication Systems, Hospital	27
4	MeSH DESCRIPTOR Medication Systems	11
5	MeSH DESCRIPTOR Electronic Prescribing	10
6	MeSH DESCRIPTOR Patient Identification Systems	3
7	((closed loop adj5 (medic* or drug* or pharmac* or prescrib* or pre-scrip*)))	0
8	(electronic-medication-administration-record*)	2
9	(emar)	1
10	((computer* adj2 (order adj entry adj system*)))	2
11	(cpoe)	11
12	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11	77
13	* IN DARE, HTA FROM 2010 TO 2015	34764
14	#12 AND #13	25

Vedlegg 2 Oversiktsartikler

Besluttningsstøtte (decision support & order sets)

Al-Bahar F, Marriott J, Curtis C, Dhillon H. **The effects of computer-aided clinical decision support systems on antibiotic prescribing in secondary care: A systematic review**. Int J Pharm Pract 2015;23:24.

Abstract: Focal points * A systematic review of international literature on clinical decision support was directed at antibiotic prescribing in secondary care. * Clinical decision support improved antibiotic prescribing in hospitals by reducing duration of treatment, defined daily dose (DDD) requirements and curtailing costs allocated to hospital antibiotics expenditure. * Clinical decision support systems have the potential to optimise antibiotic prescribing in secondary care though more detail of optimal system arrangements are needed. Introduction Antibiotic selection is a dynamically complex therapeutic process because of the potential long-term impact on antimicrobial resistance, patient safety, quality of care and cost1. Health information technology in the form of clinical decision support (CDS) presents as a promising solution to optimise antibiotic prescribing across different health care settings. CDS systems come in many formats including computerised physician order entry (CPOE), electronic prescribing (e-Rx) and computerised clinical decision support system (CDSS). There is however little consensus on the configuration of CDS or on the ultimate outcomes from its use. The aim of this study was to perform a systematic review of the international literature published on CDS systems used to support the use of antibiotics in secondary care and to perform meta-synthesis on data outputs. Methods A systematic literature search was conducted in November 2014 using eight electronic databases including MEDLINE, EMBASE, PUBMED, Web of Science, CINAHL, Cochrane Library, HMIC, and PsycINFO. The search was conducted using a strategy based upon combinations of the following terms: (Electronic prescribing) OR (Clinical decision support) AND (antibiotic or antibacterial or antimicrobial) AND (hospital or secondary care or inpatient). The reference sections of all retrieved articles were also searched for additional relevant articles. Editorials, letters, case reports and non-English language articles were excluded. Data extraction was conducted by two investigators independently (with conflicts resolved by a third researcher) and consisted of data on study design, quality, participant characteristics, interventions, outcomes and main findings. Results Thirty-eight studies were identified matching the inclusion criteria, which described a wide range of quantitative and qualitative assessments of CDS outcomes. Meta-synthesis of sub-groups highlighted 23 studies describing the four most common outcome measures used, which were the appropriateness of antibiotic treatment (11 studies - all showing more appropriate prescribing), defined daily doses (DDDs - 7 studies), cost of antibiotic treatment (6 studies - all demonstrated reduced costs) and duration of antibiotic treatment (4 studies - all showed reduced therapy duration). Five of these studies examined more than one outcome measure. Of the 7 studies quantifying DDDs prescribed, six demonstrated a reduction in DDDs but one indicated that use of CDS resulted in increased antibiotic DDD use. The remaining 15 studies identified in the review described a diverse range of 14 other outcome measures (e.g. length of patient stay, compliance with guidelines). Discussion Clinical decision support systems have been shown in this systematic review to have the potential to improve antibiotic prescribing in secondary care as measured by robust outcome measures. However, given that the majority of studies identified in this review were conducted in the USA or Australia, it is difficult to generalise the results to a UK setting. Further studies should to be conducted in order to evaluate patient specific outcomes such as mortality and also to determine which clinical decision support system characteristics are likely to maximise prescriber adoption and satisfaction.

Brown CL, Slight SP, Husband AK, Watson NW, Bates DW. **A narrative review of medication-related clinical decision support**. J Gen Intern Med 2015;30:S86-S87.

Abstract: BACKGROUND: Medication errors cause substantial patient harm and can occur at any stage of the medication use process. Health information technology, such as Computerized Physician Order Entry (CPOE) and Clinical Decision Support (CDS), may be used to reduce the likelihood of these errors. Medication-related CDS provides automated guidance and support to clinicians at the point of prescribing. CDS can provide drug-drug interaction (DDI) checks, drug allergy checks, dosing guidance, duplicate therapy checks and formulary decision support. CDS has been associated with a range of benefits such as improved patient safety, improved standards of care and reduction in healthcare costs. We reviewed the recent literature around medication-related CDS functionality and reflected upon the issues pertinent to its future development. METHODS: We searched for papers in Medline Ovid and Embase Ovid, using MeSH terms and key words including 'clinical decision support', 'decision support systems' and 'computerized physician order entry' with a date range of 2007 to 2014. Specific MeSH terms and keywords relevant to five basic CDS functionalities were also used. We included all publication types, all types of CPOE systems and all clinical settings. Only English language papers were selected for further review. Reference lists, papers from world leading experts and the 'other citing articles' function were also used to identify additional articles. Titles and abstracts were initially screened to identify relevant papers, followed by the full text by one reviewer. A total of 896 articles were identified across each of the five areas, of which 184 were included. RESULTS: The success of CDS very much depends on users finding alerts valuable and acting on the information received. CDS functionality is continually evolving in response to users' needs. Assigning a severity level to DDI alerts has been shown to improve alert acceptance. Additionally, improving alert specificity and severity was found to be an important factor for realising the benefits of DDI alerts. Maintenance of accurate records and ability to carry out cross-sensitivity checks are key to the production of appropriate drug-allergy checks. Patient specific parameters should be incorporated into the decision-making algorithms to improve the accuracy and appropriateness of drug-dosage alerts; furthermore, suggested doses should be appropriately rounded to facilitate administration and include order sentences sequenced to reflect those most commonly used. How the CDS system is configured is important for drug-duplication checks and to avoid potentially exposing the patient to toxic drug levels. The knowledge base(s) for drug-formulary alerts must be accurate and reviewed regularly in order to produce relevant alerts and encourage formulary adherence. Finally, consideration of human factors principles during the design and implementation of CDS is critical and has been shown to improve system effectiveness. CONCLUSIONS: CDS is still undergoing development. The implementation of automation in healthcare has surged in recent years and this is likely to continue. Moving forward, integration of patient specific parameters into CDS decision-making checks and consideration of human-factors design principles will be central to obtaining the potential benefits of CDS. Such advancements in CDS should enable it to have a much greater impact for improving patient care.

Ranji SR, Rennke S, Wachter RM. **Computerised provider order entry combined with clinical decision support systems to improve medication safety: a narrative review**. BMJ quality & safety 2014;23(9):773-780.

Abstract: BACKGROUND: Adverse drug events (ADEs) are a major cause of morbidity in hospitalised and ambulatory patients. Computerised provider order entry (CPOE) combined with clinical decision support systems (CDSS) are being widely implemented with the goal of preventing ADEs, but the effectiveness of these systems remains unclear., METHODS: We searched the specialised database Agency for Healthcare Research and Quality (AHRQ) Patient Safety Net to identify reviews of the effect of CPOE combined with CDSS on ADE rates in inpatient and outpatient settings. We included systematic and narrative reviews published since 2008 and controlled clinical trials published since 2012., RESULTS: We included five systematic reviews, one narrative review and two controlled trials. The existing literature consists mostly of studies of homegrown systems conducted in the inpatient setting. CPOE+CDSS was consistently reported to reduce prescribing errors, but does not appear to prevent clinical ADEs in either the inpatient or outpatient setting. Implementation of CPOE+CDSS profoundly changes staff workflow, and often leads to unintended consequences and new safety issues (such as alert fatigue) which limit the system's safety effects., CONCLUSIONS: CPOE+CDSS does not appear to reliably prevent clinical ADEs. Despite

more widespread implementation over the past decade, it remains a work in progress.Copyright Published by the BMJ Publishing Group Limited. For permission to use (where not already granted under a licence) please go to http://group.bmj.com/group/rights-licensing/permissions.

Gillaizeau F, Chan E, Trinquart L, Colombet I, Walton RT, Rege-Walther M, et al. **Computerized advice on drug dosage to improve prescribing practice**. The Cochrane database of systematic reviews 2013;11:CD002894.

Abstract: BACKGROUND: Maintaining therapeutic concentrations of drugs with a narrow therapeutic window is a complex task. Several computer systems have been designed to help doctors determine optimum drug dosage. Significant improvements in health care could be achieved if computer advice improved health outcomes and could be implemented in routine practice in a cost-effective fashion. This is an updated version of an earlier Cochrane systematic review, first published in 2001 and updated in 2008., OBJECTIVES: To assess whether computerized advice on drug dosage has beneficial effects on patient outcomes compared with routine care (empiric dosing without computer assistance)., SEARCH METHODS: The following databases were searched from 1996 to January 2012: EPOC Group Specialized Register, Reference Manager; Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, Ovid; EMBASE, Ovid; and CINAHL, EbscoHost. A "top up" search was conducted for the period January 2012 to January 2013; these results were screened by the authors and potentially relevant studies are listed in Studies Awaiting Classification. The review authors also searched reference lists of relevant studies and related reviews., SELECTION CRITERIA: We included randomized controlled trials, non-randomized controlled trials, controlled before-and-after studies and interrupted time series analyses of computerized advice on drug dosage. The participants were healthcare professionals responsible for patient care. The outcomes were any objectively measured change in the health of patients resulting from computerized advice (such as therapeutic drug control, clinical improvement, adverse reactions)., DATA COLLECTION AND ANALYSIS: Two review authors independently extracted data and assessed study quality. We grouped the results from the included studies by drug used and the effect aimed at for aminoglycoside antibiotics, amitriptyline, anaesthetics, insulin, anticoagulants, ovarian stimulation, anti-rejection drugs and theophylline. We combined the effect sizes to give an overall effect for each subgroup of studies, using a random-effects model. We further grouped studies by type of outcome when appropriate (i.e. no evidence of heterogeneity)., MAIN RESULTS: Forty-six comparisons (from 42 trials) were included (as compared with 26 comparisons in the last update) including a wide range of drugs in inpatient and outpatient settings. All were randomized controlled trials except two studies. Interventions usually targeted doctors, although some studies attempted to influence prescriptions by pharmacists and nurses. Drugs evaluated were anticoagulants, insulin, aminoglycoside antibiotics, theophylline, anti-rejection drugs, anaesthetic agents, antidepressants and gonadotropins. Although all studies used reliable outcome measures, their quality was generally low.This update found similar results to the previous update and managed to identify specific therapeutic areas where the computerized advice on drug dosage was beneficial compared with routine care:1. it increased target peak serum concentrations (standardized mean difference (SMD) 0.79, 95% CI 0.46 to 1.13) and the proportion of people with plasma drug concentrations within the therapeutic range after two days (pooled risk ratio (RR) 4.44, 95% CI 1.94 to 10.13) for aminoglycoside antibiotics;2. it led to a physiological parameter more often within the desired range for oral anticoagulants (SMD for percentage of time spent in target international normalized ratio +0.19, 95% CI 0.06 to 0.33) and insulin (SMD for percentage of time in target glucose range: +1.27, 95% CI 0.56 to 1.98);3. it decreased the time to achieve stabilization for oral anticoagulants (SMD -0.56, 95% CI -1.07 to -0.04);4. it decreased the thromboembolism events (rate ratio 0.68, 95% CI 0.49 to 0.94) and tended to decrease bleeding events for anticoagulants although the difference was not significant (rate ratio 0.81, 95% CI 0.60 to 1.08). It tended to decrease unwanted effects for aminoglycoside antibiotics (nephrotoxicity: RR 0.67, 95% CI 0. 2 to 1.06) and anti-rejection drugs (cytomegalovirus infections: RR 0.90, 95% CI 0.58 to 1.40);5. it tended to reduce the length of time spent in the hospital although the difference was not significant (SMD -0.15, 95% CI -0.33 to 0.02) and to achieve comparable or better cost-effectiveness ratios than usual care;6. there was no evidence of differences in mortality or other clinical adverse events for insulin (hypoglycaemia), anaesthetic agents, anti-rejection drugs and antidepressants.For all outcomes, statistical heterogeneity quantified by I(2) statistics was moderate to high., AUTHORS' CONCLUSIONS: This review update suggests that computerized advice for drug dosage has some benefits: it increases the serum concentrations for aminoglycoside antibiotics and improves

the proportion of people for which the plasma drug is within the therapeutic range for aminoglycoside antibiotics.It leads to a physiological parameter more often within the desired range for oral anticoagulants and insulin. It decreases the time to achieve stabilization for oral anticoagulants. It tends to decrease unwanted effects for aminoglycoside antibiotics and anti-rejection drugs, and it significantly decreases thromboembolism events for anticoagulants. It tends to reduce the length of hospital stay compared with routine care while comparable or better cost-effectiveness ratios were achieved. However, there was no evidence that decision support had an effect on mortality or other clinical adverse events for insulin (hypoglycaemia), anaesthetic agents, anti-rejection drugs and antidepressants. In addition, there was no evidence to suggest that some decision support technical features (such as its integration into a computer physician order entry system) or aspects of organization of care (such as the setting) could optimize the effect of computerized advice.Taking into account the high risk of bias of, and high heterogeneity between, studies, these results must be interpreted with caution.

Adams P, Riggio JM, Thomson L, Brandell-Marino R, Merli G. **Clinical decision support systems to improve utilization of thromboprophylaxis: a review of the literature and experience with implementation of a computerized physician order entry program**. Hospital practice (1995) 2012;40(3):27-39.

Abstract: OBJECTIVE: A literature review was conducted of studies investigating the effectiveness of paper- and computer-based clinical decision support systems (CDSS) used with or without educational programs designed to increase the use of venous thromboembolism (VTE) prophylaxis., METHODS: Medline was searched on August 9, 2010, without limits on publication year, but with restrictions to English-language articles only. The search terms used were "venous thromboembolism," "deep vein thrombosis," "pulmonary embolism," "prophylaxis," "thromboprophylaxis," "computerized," "computerised," "decision support," "alerts," "reminder," "paper system," "risk assessment," and "risk score." All types of studies regarding the effects of CDSS on VTE prophylaxis rates were included. Studies were included if > 1 post-implementation outcome was measured, such as rates of VTE, rates of prophylaxis prescribing, or guideline-adherence measures., RESULTS: Studies evaluating paper-based CDSS used different strategies, including risk-assessment forms with prophylaxis recommendations, standard order sets, and preprinted sticker reminders on patient notes. Paper-based systems consistently improved prophylaxis rates; however, in most studies, there was still room for improvement. Furthermore, the effect of paper-based CDSS on VTE rates was not conclusively established. Studies evaluating computer-based systems used approaches including risk-assessment models integrated in the computerized physician order entry system, with or without alerts, and automatic reminders on operating schedules., CONCLUSION: Computerized systems are associated with substantial improvements in the prescribing of appropriate prophylaxis and reductions in VTE events, particularly in medical patients. More robust systems can be established with computer-based rather than paper-based CDSS. A drawback of computerized systems is that some hospitals may not have adequate information technology system resources.

Chan AJ, Chan J, Cafazzo JA, Rossos PG, Tripp T, Shojania K, et al. **Order sets in health care: a systematic review of their effects**. Int J Technol Assess Health Care 2012;28(3):235-240.

Abstract: OBJECTIVES: Order sets are widely used in hospitals to enter diagnosis and treatment orders. To determine the effectiveness of order sets in improving guideline adherence, treatment outcomes, processes of care, efficiency, and cost, we conducted a systematic review of the literature., METHODS: A comprehensive literature search was performed in various databases for studies published between January 1, 1990, and April 18, 2009. A total of eighteen studies met inclusion criteria. No randomized controlled trials were found., RESULTS: Outcomes of the included studies were summarized qualitatively due to variations in study population, intervention type, and outcome measures. There were no important inconsistencies between the results reported by studies involving different types of order sets. While the studies generally suggested positive outcomes, they were typically of low quality, with simple before-after designs and other methodological limitations., CONCLUSIONS: The benefits of order sets remain eminently plausible, but given the paucity of high quality evidence, further investigations to formally evaluate the effectiveness of order sets would be highly valuable.

Nirantharakumar K, Chen YF, Marshall T, Webber J, Coleman JJ. **Clinical decision support systems in the care of inpatients with diabetes in non-critical care setting: systematic review**. Diabetic medicine : a journal of the British Diabetic Association 2012;29(6):698-708.

Abstract: BACKGROUND: Computerized clinical decision support systems have been claimed to reduce prescription errors and improve patient care. They may play an important role in the care of hospitalized patients with diabetes., AIM: To collate evidence for the use of clinical decision support systems in improving the care of hospitalized patients with diabetes in a non-critical care setting and to assess their effectiveness., METHODS: We searched four databases from 1980 to 2010 without language restrictions. All types of studies other than case reports were included. Data extraction and quality assessment were carried out based on the Centre for Review and Dissemination guidance. A narrative synthesis was conducted., RESULTS: Fourteen studies met the inclusion criteria, including two cluster randomized controlled trials, eight before-and-after studies and four other descriptive studies. Generally, the quality of the studies was not very high. Nine out of 10 studies reported reduction in mean blood glucose or similar measures (patient-day-weighted mean blood glucose) during inpatient stay. The reduction using computerized physician order entry system in patient-day-weighted mean blood glucose ranged from 0.6 to 0.8 mmol/l (10.8-15.6 mg/dl). Other beneficial effects during inpatient stay included reduced use of sliding scale insulin and greater use of basal-bolus insulin regimen. Only one study found a significant increase in hypoglycaemic events., CONCLUSIONS: Clinical decision support systems have been used, often as part of a complex programme, to improve the care of hospitalized patients with diabetes. There is some evidence that they may have a beneficial effect, but this needs further confirmation.

Stultz JS, Nahata MC. **Computerized clinical decision support for medication prescribing and utilization in pediatrics**. Journal of the American Medical Informatics Association : JAMIA 2012;19(6):942-953.

Abstract: BACKGROUND AND OBJECTIVE: Accurate and informed prescribing is essential to ensure the safe and effective use of medications in pediatric patients. Computerized clinical decision support (CCDS) functionalities have been embedded into computerized physician order entry systems with the aim of ensuring accurate and informed medication prescribing. Owing to a lack of comprehensive analysis of the existing literature, this review was undertaken to analyze the effect of CCDS implementation on medication prescribing and use in pediatrics., MATERIALS AND METHODS: A literature search was performed using keywords in PubMed to identify research studies with outcomes related to the implementation of medication-related CCDS functionalities., RESULTS AND DISCUSSION: Various CCDS functionalities have been implemented in pediatric patients leading to different results. Medication dosing calculators have decreased calculation errors. Alert-based CCDS functionalities, such as duplicate therapy and medication allergy checking, may generate excessive alerts. Medication interaction CCDS has been minimally studied in pediatrics. Medication dosing support has decreased adverse drug events, but has also been associated with high override rates. Use of medication order sets have improved guideline adherence. Guideline-based treatment recommendations generated by CCDS functionalities have had variable influence on appropriate medication use, with few studies available demonstrating improved patient outcomes due to CCDS use., CONCLUSION: Although certain medication-related CCDS functionalities have shown benefit in medication prescribing for pediatric patients, others have resulted in high override rates and inconsistent or unknown impact on patient care. Further studies analyzing the effect of individual CCDS functionalities on safe and effective prescribing and medication use are required.

Jaspers MWM, Smeulers M, Vermeulen H, Peute LW. **Effects of clinical decision-support systems on practitioner performance and patient outcomes: a synthesis of high-quality systematic review findings**. Journal of the American Medical Informatics Association : JAMIA 2011;18(3):327-334.

Abstract: OBJECTIVE: To synthesize the literature on clinical decision-support systems' (CDSS) impact on healthcare practitioner performance and patient outcomes., DESIGN: Literature search on Medline, Embase, Inspec, Cinahl, Cochrane/Dare and analysis of high-quality systematic reviews (SRs) on CDSS in hospital settings. Two-stage inclusion procedure: (1) selection of publications on predefined inclusion criteria; (2) independent meth-

odological assessment of preincluded SRs by the 11-item measurement tool, AMSTAR. Inclusion of SRs with AMSTAR score 9 or above. SRs were thereafter rated on level of evidence. Each stage was performed by two independent reviewers., RESULTS: 17 out of 35 preincluded SRs were of high methodological quality and further analyzed. Evidence that CDSS significantly impacted practitioner performance was found in 52 out of 91 unique studies of the 16 SRs examining this effect (57%). Only 25 out of 82 unique studies of the 16 SRs reported evidence that CDSS positively impacted patient outcomes (30%)., CONCLUSIONS: Few studies have found any benefits on patient outcomes, though many of these have been too small in sample size or too short in time to reveal clinically important effects. There is significant evidence that CDSS can positively impact healthcare providers' performance with drug ordering and preventive care reminder systems as most clear examples. These outcomes may be explained by the fact that these types of CDSS require a minimum of patient data that are largely available before the advice is (to be) generated: at the time clinicians make the decisions.

Robertson J, Walkom E, Pearson S-A, Hains I, Williamsone M, Newby D. **The impact of pharmacy computerised clinical decision support on prescribing, clinical and patient outcomes: a systematic review of the literature**. The International journal of pharmacy practice 2010;18(2):69-87.

Abstract: OBJECTIVES: Computerised clinical decision support systems (CDSSs) are being used increasingly to support evidence-based decision-making by health care professionals. This systematic review evaluated the impact of CDSSs targeting pharmacists on physician prescribing, clinical and patient outcomes. We compared the impact of CDSSs addressing safety concerns (drug interactions, contraindications, dose monitoring and adjustment) and those focusing on medicines use in line with guideline recommendations (hereafter referred to as Quality Use of Medicines, or QUM). We also examined the influence of clinical setting (institutional versus ambulatory care), system- or user-initiation of CDSS, prescribing versus clinical outcomes reported and use of multi-faceted versus single interventions on system effectiveness., METHODS: We searched Medline, Embase, CINAHL and PsycINFO (1990-2009) for methodologically adequate studies (experiments and strong quasi-experiments) comparing a CDSS with usual pharmacy care. Individual study results are reported as positive trends or statistically significant results in the direction of the intentions of the CDSS being tested. Studies are aggregated and compared as the proportions of studies showing the effectiveness of the CDSS on the majority (> or = 50%) of outcomes reported in the individual study., KEY FINDINGS: Of 21 eligible studies, 11 addressed safety and 10 QUM issues. CDSSs addressing safety issues were more effective than CDSSs focusing on QUM (10/11 versus 4/10 studies reporting statistically significant improvements in favour of CDSSs on > or = 50% of all outcomes reported; P = 0.01). A number of QUM studies noted the limited contact between pharmacists and physicians relating to QUM treatment recommendations. More studies demonstrated CDSS benefits on prescribing outcomes than clinical outcomes (10/10 versus 0/3 studies; P = 0.002). There were too few studies to assess the impact of system- versus user-initiated CDSS, the influence of setting or multi-faceted interventions on CDSS effectiveness., CONCLUSIONS: Our study demonstrated greater effectiveness of safety-focused compared with QUM-focused CDSSs. Medicine safety issues are traditional areas of pharmacy activity. Without good communication between pharmacists and physicians, the full benefits of QUM-focused CDSSs may not be realised. Developments in pharmacy-based CDSSs need to consider these inter-professional relationships as well as computer-system enhancements.

Elektronisk foreskrivning

Alshahrani F, Marriott J, Cox A. **The impact of electronic prescribing systems on the incidence of prescribing errors within in-patients settings: A systematic review**. Int J Pharm Pract 2015;23:26-27.

Abstract: Focal points * The systematic review aimed to evaluate the effects electronic prescribing systems on the incidence of prescribing errors among hospitalised patients. * Error analysis indicated that the use of e-prescribing systems introduced different types of prescribing error. * E-prescribing systems are effective tools in reducing the incidence of prescribing errors in hospitalised patients but it is vital that future research adopts more rigorous designs and standardised definitions of prescribing error. Introduction Medication errors are a major concern in health care organisations internationally: these can be associated

with dispensing, administration and in particular prescribing. Their occurrence is common within secondary care1 presenting as a significant challenge to healthcare providers and a potential threat to patient safety. A recent systematic review of the prevalence, incidence, and nature of prescribing errors in hospital inpatients revealed that the median error rates were 7 %of medication orders, 52 errors per 100 admissions, and 24 errors per 1,000 patient days2. Moreover, the errors that do not result in injury to patients can lead to an additional work and/or increase the cost of patients' care. Using information technology in prescribing was one of the proposed strategies to reduce prescribing errors and improve patients' safety. The present research focused on the impact of electronic prescribing on the incidence and nature of prescribing errors. The aim of this systematic review was to evaluate the effects electronic prescribing systems on the incidence of prescribing errors among hospitalised patients. Methods A systematic literature search was conducted in November 2014 using eight electronic databases including CINAHL, EMBASE, ASSIA, HMIC, Psyc INFO, MEDLINE, Web of Science and Cochrane library. Two investigators conducted data extraction independently (with conflicts resolved by a third researcher). Eligible studies included those evaluating prescribing errors using electronic prescribing systems conducted in hospital inpatient settings, studies evaluating pre and post implementation of e-prescribing system or comparative investigations (handwritten vs e-prescribing) and studies evaluating the numbers, frequency or rates of prescribing errors arising from medical or non-medical prescribing. The reference sections of all retrieved articles were also searched for additional relevant articles. Studies detecting prescribing errors on paper-based systems, those conducted in primary care, emergency department, and ambulatory care or aged care settings were excluded. Non-English literature as well as editorial, personal opinion and letters were also excluded. Results Thirty-nine studies met the inclusion criteria. Most studies (85%) were conducted at a single hospital site. Arange of study designs was used to detect prescribing errors of which 54% were of a prospective design. 59% (23/39) of the studies examined adult patients, 31% (12/39) involved paediatric patients and 10% (4/39) screened both populations. The majority of studies (85%, 33/39) demonstrated a significant reduction on the incidence of prescribing errors associated with the use of electronic prescribing systems however, 15% (6/39) showed an increased rate or no effects on the incidence of prescribing errors. Analysis of the errors encountered in the study outputs, indicated that the use of e-prescribing systems introduced different types of error (e.g. selection errors from a drop down menu or orders duplication) compared to those found when operating conventional paper based prescribing. Discussion The present study indicated that electronic prescribing systems generally are effective tools in reducing the incidence of prescribing errors in hospitalised patients thus improving patient safety. This review found that a wide range of electronic prescribing systems with differing features was used in the study outputs. Importantly, a lack of standardised definition and severity scales for prescribing errors was also encountered. ince different study designs (e.g. prospective or retrospective) and methods of error detection (e.g. observation or incidence reports) yield different results it is vital that future research adopts more rigorous designs and standardised definitions of prescribing error.

Iankowitz N, Dowden M, Palomino S, Uzokwe H, Worral P. **The effectiveness of computer system tools on potentially inappropriate medications ordered at discharge for adults older than 65 years of age: A systematic review**. JBI Library of Systematic Reviews 2015;10(13):798-831.

Abstract: Background Prescribing potentially inappropriate medications to the elderly leads to adverse health outcomes. The use of computer systems decision making tools has been shown to decrease the incidence of prescribing potentially inappropriate medications for the elderly; however, these results are often dependent upon other variables, such as provider compliance Objective To examine and synthesize the best available evidence related to the effect of computer systems clinical decision making tools on frequency of ordering potentially inappropriate medications at discharge and related unplanned emergency room visits or hospital readmissions in community dwelling patients older than 65 years of age. Inclusion criteria Types of participants Adults older than 65 years of age prescribed potentially inappropriate medications. Types of interventions Electronic or computer based clinical decision making supplement or support related to prescribing of potentially inappropriate medications. Types of outcomes The outcome measures were frequency of ordering potentially inappropriate medications (PIMs) for patients at discharge, unexpected hospital readmission rate and unexpected emergency room visits of patients who were discharged on PIMs. Types of studies Randomised control trials and quasi-experimental studies. Search strategy The

search strategy aimed to find both published and unpublished studies in the English language from January 2003 through July 2011. A search of PubMED, CINAHL, Health Source Nursing/Academic Edition, MasterFILE Premier, Scopus, DARE, Academic Search Premier, Scirus, Embase was conducted. Methodological quality Studies were critically evaluated by two independent reviewers using standardised critical appraisal instruments from the Joanna Briggs Institute. Data Collection Data were extracted using the standardised data extraction instruments from the Joanna Briggs Institute. Data Synthesis Results from quantitative papers were pooled in statistical meta-analysis as appropriate using JBI-MAStARI. Where statistical pooling was not possible, the findings are presented in narrative form. Results A total of five articles, four randomised control studies and one quasi-experimental study were included. One study demonstrated that a computerised alert tool along with collaboration of the health care providers resulted in a statistically significant (p=0.002) decrease in ordering of PIMs as well as improved medication safety in patients older than 65 years of age. Similarly, a randomised controlled study demonstrated that computerised physician order entry with decision support significantly (p=0.02) reduced prescribing of PIMs for seniors (odds ratio=0.55, 95% CI=0.34 - 0.89). Another study demonstrated that computer-based access to complete drug profiles and alerts reduced the rate of initiation of potentially inappropriate prescriptions by 18% (RR=0.82, 95% CI=0.69-0.98). Yet another study demonstrated that implementation of age specific alerts decreases prescription writing of PIMs from 21.9 prescriptions to 16.8 per 10,000 patients; p value < 0.01. One study demonstrated that age specific alerts reduced prescribing of PIMs from 150.2 to 137.2 prescriptions per 10,000 patients; the p value = 0.75 was not statistically significant. Results from two trials were pooled for meta-analysis, with summary RR = 0.82, and 95%CI (0.76 - 0.88). No studies were found that specifically addressed unexpected hospital readmission or unexpected visits to the emergency room of patients who were discharged on PIMs. Conclusions Reduction in prescribing of potentially inappropriate medications occurs when clinical decision making computer support tools, such as drug specific alerts, are available to providers. Implications for practice Computer systems clinical decision making tools have potential for reducing numbers of potentially inappropriate medications prescribed for the community based population older than 65 years of age. Implications for research Future research should continue to explore the effects of computerized cli ical decision making tools on prescription writing habits of practitioners for the elderly population. In addition, documentation of unplanned ER visits and unplanned readmission rates needs to be correlated with the use of potentially inappropriate medications.

Kukreti V, Cosby R, Cheung A, Lankshear S, Group STCPOEGD. **Computerized prescriber order entry in the outpatient oncology setting: from evidence to meaningful use**. Curr Oncol 2014;21(4):e604-612.

Abstract: BACKGROUND: Chemotherapy is an effective treatment in the fight against many cancers. Medication errors in oncology can be particularly serious given the narrow therapeutic window of antineoplastic drugs and their high toxicities. Computerized prescriber order entry (cpoe) has consistently been shown to reduce medication errors and adverse drug events in various settings, but its use in the oncology setting has not been well established. To gain a better understanding of the meaningful use of cpoe systems in the outpatient chemotherapy setting, we undertook a systematic review of systemic therapy cpoe., METHODS: A province-wide expert panel consisting of clinical experts, health information professionals, and specialists in human factors design provided guidance in the development of the research questions, search terms, databases, and inclusion criteria. The systematic review was undertaken by a core team consisting of a medical oncologist, nurse, pharmacist, and methodologist. The medline, embase, cinahl, and compendex databases were searched for relevant evidence., RESULTS: The database searches resulted in 5642 hits, of which 9 met the inclusion criteria and were retained. In the oncology setting, cpoe systems generally reduce chemotherapy medication errors; however, specific types of errors increase with the use of cpoe. These systems affect practice both positively and negatively with respect to time, workload, and productivity., CONCLUSIONS: Despite the paucity of oncology-specific research, cpoe should be used in outpatient chemotherapy delivery to reduce chemotherapy-related medication errors. Adoption by clinicians will be enhanced by cpoe processes that complement current practice and workflow processes.

Nuckols TK, Smith-Spangler C, Morton SC, Asch SM, Patel VM, Anderson LJ, et al. **The effectiveness of computerized order entry at reducing preventable adverse drug**

events and medication errors in hospital settings: a systematic review and meta-analysis. Systematic reviews 2014;3:56.

Abstract: BACKGROUND: The Health Information Technology for Economic and Clinical Health (HITECH) Act subsidizes implementation by hospitals of electronic health records with computerized provider order entry (CPOE), which may reduce patient injuries caused by medication errors (preventable adverse drug events, pADEs). Effects on pADEs have not been rigorously quantified, and effects on medication errors have been variable. The objectives of this analysis were to assess the effectiveness of CPOE at reducing pADEs in hospital-related settings, and examine reasons for heterogeneous effects on medication errors., METHODS: Articles were identified using MEDLINE, Cochrane Library, Econlit, web-based databases, and bibliographies of previous systematic reviews (September 2013). Eligible studies compared CPOE with paper-order entry in acute care hospitals, and examined diverse pADEs or medication errors. Studies on children or with limited event-detection methods were excluded. Two investigators extracted data on events and factors potentially associated with effectiveness. We used random effects models to pool data., RESULTS: Sixteen studies addressing medication errors met pooling criteria; six also addressed pADEs. Thirteen studies used pre-post designs. Compared with paper-order entry, CPOE was associated with half as many pADEs (pooled risk ratio (RR)=0.47, 95% CI 0.31 to 0.71) and medication errors (RR=0.46, 95% CI 0.35 to 0.60). Regarding reasons for heterogeneous effects on medication errors, five intervention factors and two contextual factors were sufficiently reported to support subgroup analyses or meta-regression. Differences between commercial versus homegrown systems, presence and sophistication of clinical decision support, hospital-wide versus limited implementation, and US versus non-US studies were not significant, nor was timing of publication. Higher baseline rates of medication errors predicted greater reductions (P<0.001). Other context and implementation variables were seldom reported., CONCLUSIONS: In hospital-related settings, implementing CPOE is associated with a greater than 50% decline in pADEs, although the studies used weak designs. Decreases in medication errors are similar and robust to variations in important aspects of intervention design and context. This suggests that CPOE implementation, as subsidized under the HITECH Act, may benefit public health. More detailed reporting of the context and process of implementation could shed light on factors associated with greater effectiveness.

Porterfield A, Engelbert K, Coustasse A. **Electronic prescribing: improving the efficiency and accuracy of prescribing in the ambulatory care setting**. Perspectives in health information management / AHIMA, American Health Information Management Association 2014;11:1g.

Abstract: Electronic prescribing (e-prescribing) is an important part of the nation's push to enhance the safety and quality of the prescribing process. E-prescribing allows providers in the ambulatory care setting to send prescriptions electronically to the pharmacy and can be a stand-alone system or part of an integrated electronic health record system. The methodology for this study followed the basic principles of a systematic review. A total of 47 sources were referenced. Results of this research study suggest that e-prescribing reduces prescribing errors, increases efficiency, and helps to save on healthcare costs. Medication errors have been reduced to as little as a seventh of their previous level, and cost savings due to improved patient outcomes and decreased patient visits are estimated to be between $140 billion and $240 billion over 10 years for practices that implement e-prescribing. However, there have been significant barriers to implementation including cost, lack of provider support, patient privacy, system errors, and legal issues.

Georgiou A, Prgomet M, Paoloni R, Creswick N, Hordern A, Walter S, et al. **The effect of computerized provider order entry systems on clinical care and work processes in emergency departments: a systematic review of the quantitative literature**. Ann Emerg Med 2013;61(6):644-653.e616.

Abstract: STUDY OBJECTIVE: We undertake a systematic review of the quantitative literature related to the effect of computerized provider order entry systems in the emergency department (ED)., METHODS: We searched MEDLINE, EMBASE, Inspec, CINAHL, and CPOE.org for English-language studies published between January 1990 and May 2011., RESULTS: We identified 1,063 articles, of which 22 met our inclusion criteria. Sixteen used a pre/post design; 2 were randomized controlled trials. Twelve studies reported outcomes related to patient flow/clinical work, 7 examined decision support systems, and 6 reported effects on patient safety. There were no studies that measured decision support systems and its effect on patient flow/clinical work. Computerized provider order entry was associated with

an increase in time spent on computers (up to 16.2% for nurses and 11.3% for physicians), with no significant change in time spent on patient care. Computerized provider order entry with decision support systems was related to significant decreases in prescribing errors (ranging from 17 to 201 errors per 100 orders), potential adverse drug events (0.9 per 100 orders), and prescribing of excessive dosages (31% decrease for a targeted set of renal disease medications)., CONCLUSION: There are tangible benefits associated with computerized provider order entry/decision support systems in the ED environment. Nevertheless, when considered as part of a framework of technical, clinical, and organizational components of the ED, the evidence base is neither consistent nor comprehensive. Multimethod research approaches (including qualitative research) can contribute to understanding of the multiple dimensions of ED care delivery, not as separate entities but as essential components of a highly integrated system of care.

Hermanowski TR, Kowalczyk M, Szafraniec-Burylo SI, Krancberg AN, Pashos CL. **Current status and evidence of effects of e-prescribing implementation in United Kingdom, Italy, Germany, Denmark, Poland and United States**. Value Health 2013;16 (7):A462-A463.

Abstract: Objectives: Electronic-prescribing (E-prescribing) in comparison to manual ("by hand") generation, transmission and filling of prescriptions is thought to substantially lower the risks of inaccuracy and therefore reduce associated health care resource use and costs. The purpose of this work is to describe the current state of e-prescribing systems implementation in Denmark, Germany, Italy, Poland, United Kingdom (UK) and United States (USA), and to assess present evidence of its influence on health care. Methods: A systematic review supplemented by additional hand-search was conducted to find relevant articles. Medline, Embase, The Cochrane Library and Scopus were searched. Quality was assessed on the basis of PRISMA, MOOSE and STROBE checklists and West 2002 recommendations. Results: Thirtyone relevant full texts were identified during systematic review, and then as a result of hand-search, 5 publications were added. E-prescribing varies considerably across these countries. It is currently voluntary in Germany, Italy and United States. In United Kingdom the system is implemented except for electronic signature. In Denmark e-prescribing is mandatory for primary care providers. Model implementation in Poland is expected to take place in 2014. Of these 36 sources, 4 articles assessing e-prescribing were of the highest quality, as judged using the assessment methods. Positive influence on medical visits frequency, quality of care, patient satisfaction, prescription errors frequency, and prescriber-pharmacy-patient communication was described in literature; most studies were conducted in the UK and USA. No data about effects of implementation for Germany, Italy, Denmark and Poland were found. Conclusions: Implementation of e-prescribing is in process in the majority of described countries. Although few studies exist that definitely demonstrate positive impact of e-prescribing on health care, gathered papers do indicate positive effects. More comprehensive assessments would be valuable in showing the attributes of e-prescribing that are most valuable, and those that may be strengthened.

Poon C, Sabbah D, Wallace C, Duffett M. **The effect of prescriber order entry on antibiotic turn-around time: A meta-analysis**. Can J Hosp Pharm 2013;66 (4):270.

Abstract: Background: Early administration of antibiotics is associated with decreased mortality. Computerized Prescriber Order Entry (CPOE) has the potential to decrease antibiotic turn-around time (TAT). However, the effect is uncertain as CPOE may also have unintended consequences such as unfavourable workflow and new kinds of errors which may lengthen antibiotic TAT. Objective: To evaluate the potential impact of pre- and post-CPOE on antibiotic TAT from when it is ordered to the time it is administered. Methods: We searched PubMed, EMBASE, International Pharmaceutical Abstracts, and the CINALH database. We included all pre- and post-intervention study designs examining antibiotic TAT. Two reviewers independently searched and screened for relevant studies between 1947-2012. The quality of the studies was assessed using a modified Newcastle-Ottawa Scale. The primary outcome was time from antibiotic order to administration of the first dose. The secondary outcome was the time from medication order to pharmacy verification. Results: We included 5 studies out of 87 unique citations. All were pre-post intervention observational studies conducted in critical care or non-critical care wards in hospital. The combined number of orders (N) in the pre-CPOE was 756 and post-CPOE was 1204. The mean antibiotic TAT was 49.86 minutes faster in favour of CPOE (95% confidence interval = 88.14 to 11.57;

p-value = 0.01). Analysis of the secondary outcome demonstrated that of these 49.86 minutes 40.11 minutes (95% confidence interval = 63.88 to 16.34; p-value = 0.0009) were attributed to the time from the order entry to pharmacist verification. Conclusion: The implementation of CPOE was associated earlier administration of antibiotics in hospitalized patients. The majority of the reduction in antibiotic TAT was at the medication order to the pharmacy verification step.

Radley DC, Wasserman MR, Olsho LE, Shoemaker SJ, Spranca MD, Bradshaw B. **Reduction in medication errors in hospitals due to adoption of computerized provider order entry systems**. Journal of the American Medical Informatics Association : JAMIA 2013;20(3):470-476.

Abstract: OBJECTIVE: Medication errors in hospitals are common, expensive, and sometimes harmful to patients. This study's objective was to derive a nationally representative estimate of medication error reduction in hospitals attributable to electronic prescribing through computerized provider order entry (CPOE) systems., MATERIALS AND METHODS: We conducted a systematic literature review and applied random-effects meta-analytic techniques to derive a summary estimate of the effect of CPOE on medication errors. This pooled estimate was combined with data from the 2006 American Society of Health-System Pharmacists Annual Survey, the 2007 American Hospital Association Annual Survey, and the latter's 2008 Electronic Health Record Adoption Database supplement to estimate the percentage and absolute reduction in medication errors attributable to CPOE., RESULTS: Processing a prescription drug order through a CPOE system decreases the likelihood of error on that order by 48% (95% CI 41% to 55%). Given this effect size, and the degree of CPOE adoption and use in hospitals in 2008, we estimate a 12.5% reduction in medication errors, or ~17.4 million medication errors averted in the USA in 1 year., DISCUSSION: Our findings suggest that CPOE can substantially reduce the frequency of medication errors in inpatient acute-care settings; however, it is unclear whether this translates into reduced harm for patients., CONCLUSIONS: Despite CPOE systems' effectiveness at preventing medication errors, adoption and use in US hospitals remain modest. Current policies to increase CPOE adoption and use will likely prevent millions of additional medication errors each year. Further research is needed to better characterize links to patient harm.

Georgiou A, Prgomet M, Markewycz A, Adams E, Westbrook JI. **The impact of computerized provider order entry systems on medical-imaging services: a systematic review**. Journal of the American Medical Informatics Association : JAMIA 2011;18(3):335-340.

Abstract: BACKGROUND: Computerized provider order entry (CPOE) systems have been strongly promoted as a means to improve the quality and efficiency of healthcare., METHODS: This systematic review aimed to assess the evidence of the impact of CPOE on medical-imaging services and patient outcomes., RESULTS: Fourteen studies met the inclusion criteria, most of which (10/14) used a pre-/postintervention comparison design. Eight studies demonstrated benefits, such as decreased test utilization, associated with decision-support systems promoting adherence to test ordering guidelines. Three studies evaluating medical-imaging ordering and reporting times showed statistically significant decreases in turnaround times., CONCLUSIONS: The findings reveal the potential for CPOE to contribute to significant efficiency and effectiveness gains in imaging services. The diversity and scope of the research evidence can be strengthened through increased attention to the circumstances and mechanisms that contribute to the success (or otherwise) of CPOE and its contribution to the enhancement of patient care delivery.

Khajouei R, Jaspers MWM. **The impact of CPOE medication systems' design aspects on usability, workflow and medication orders: a systematic review**. Methods Inf Med 2010;49(1):3-19.

Abstract: OBJECTIVES: To examine the impact of design aspects of computerized physician order entry (CPOE) systems for medication ordering on usability, physicians' workflow and on medication orders., METHODS: We systematically searched PubMed, EMBASE and Ovid MEDLINE for articles published from 1986 to 2007. We also evaluated reference lists of reviews and relevant articles captured by our search strategy, and the web-based inventory of evaluation studies in medical informatics 1982-2005. Data about design aspects were extracted from the relevant articles. Identified design aspects were categorized in groups derived from principles for computer screen and dialogue design and user guidance from the

International Standard Organization, and if CPOE-specific, from the collected data., RESULTS: A total of 19 papers met our inclusion criteria. Sixteen studies used qualitative evaluation methods and the rest both qualitative and quantitative. In total 42 CPOE design aspects were identified and categorized in seven groups: 1) documentation and data entry components, 2) alerting, 3) visual clues and icons, 4) drop-down lists and menus, 5) safeguards, 6) screen displays, and 7) auxiliary functions., CONCLUSIONS: Beside the range of functionalities provided by a CPOE system, their subtle design is important to increase physicians' adoption and to reduce medication errors. This requires continuous evaluations to investigate whether interfaces of CPOE systems follow normal flow of actions in the ordering process and if they are cognitively easy to understand and use for physicians. This paper provides general recommendations for CPOE (re)design based on the characteristics of CPOE design aspects found.

Elektroniske alarmsystemer

Bayoumi I, Al Balas M, Handler SM, Dolovich L, Hutchison B, Holbrook A. **The effectiveness of computerized drug-lab alerts: a systematic review and meta-analysis**. Int J Med Inform 2014;83(6):406-415.

Abstract: BACKGROUND: Inadequate lab monitoring of drugs is a potential cause of ADEs (adverse drug events) which is remediable., OBJECTIVES: To determine the effectiveness of computerized drug-lab alerts to improve medication-related outcomes., DATA SOURCES: Citations from the Computerized Clinical Decision Support System Systematic Review (CCDSSR) and MMIT (Medications Management through Health Information Technology) databases, which had searched MEDLINE, EMBASE, CINAHL, Cochrane Database of Systematic Reviews, International Pharmaceutical Abstracts from 1974 to March 27, 2013., STUDY SELECTION: Randomized controlled trials (RCTs) of clinician-targeted computerized drug lab alerts conducted in any healthcare setting. Two reviewers performed full text review to determine study eligibility., DATA ABSTRACTION: A single reviewer abstracted data and evaluated validity of included studies using Cochrane handbook domains., DATA SYNTHESIS: Thirty-six studies met the inclusion criteria (25 single drug studies with 22,504 participants, 14 targeting anticoagulation; 11 multi-drug studies with 56,769 participants). ADEs were reported as an outcome in only four trials, all targeting anticoagulants. Computerized drug-lab alerts did not reduce ADEs (OR 0.89, 95% CI 0.79-1.00, p=0.05), length of hospital stay (SMD 0.00, 95%CI -0.93 to 0.93, p=0.055, 1 study), likelihood of hypoglycemia (OR 1.29, 95% CI 0.31-5.37) or likelihood of bleeding, but were associated with increased likelihood of prescribing changes (OR 1.73, 95% CI 1.21-2.47) or lab monitoring (OR 1.47, 95% confidence interval 1.12-1.94) in accordance with the alert., CONCLUSIONS: There is no evidence that computerized drug-lab alerts are associated with important clinical benefits, but there is evidence of improvement in selected clinical surrogate outcomes (time in therapeutic range for vitamin K antagonists), and changes in process outcomes (lab monitoring and prescribing decisions).

Ojeleye O, Avery A, Gupta V, Boyd M. **The evidence for the effectiveness of safety alerts in electronic patient medication record systems at the point of pharmacy order entry: a systematic review**. BMC Med Inform Decis Mak 2013;13:69.

Abstract: BACKGROUND: Electronic Patient Medication Record (ePMR) systems have important safety features embedded to alert users about potential clinical hazards and errors. To date, there is no synthesis of evidence about the effectiveness of these safety features and alerts at the point of pharmacy order entry. This review aims to systematically explore the literature and synthesise published evidence about the effectiveness of safety features and alerts in ePMR systems at the point of pharmacy order entry, in primary and secondary care., METHODS: We searched MEDLINE, EMBASE, Inspec, International Pharmaceutical Abstracts, PsycINFO, CINHAL (earliest entry to March 2012) and reference lists of articles. Two reviewers examined the titles and abstracts, and used a hierarchical template to identify comparative design studies evaluating the effectiveness of safety features and alerts at the point of pharmacy order entry. The two reviewers independently assessed the quality of the included studies using Cochrane Collaboration's risk of bias tool., RESULTS: Three randomised trials and two before-after studies met our criteria. Four studies involved integrated care facilities and one was hospital-based. The studies were all from the United States (US). The five studies demonstrated statistically significant reduction in medication errors in patients with renal insufficiency, pregnant women dispensed US Food Drug and Administration

(FDA) risk category D (evidence of fetal risk but therapeutic benefits can outweigh the risk) or X (evidence suggests that risk to the fetus outweighs therapeutic benefits) medication, first dispensing of inappropriate medications in patients aged 65 and above, co-dispensing of interacting drugs, and adverse drug events related to hyperkalaemia., CONCLUSIONS: This systematic review shows that the safety features of ePMR systems are effective in alerting users about potential clinical hazards and errors during pharmacy order entry. There are however, problems such as false alerts and inconsistencies in alert management. More studies are needed from other countries and pharmacy practice settings to assess the effectiveness of electronic safety features and alerts in preventing error and reducing harm to patients.

Forster AJ, Jennings A, Chow C, Leeder C, van Walraven C. **A systematic review to evaluate the accuracy of electronic adverse drug event detection**. Journal of the American Medical Informatics Association : JAMIA 2012;19(1):31-38.

Abstract: OBJECTIVE: Adverse drug events (ADEs), defined as adverse patient outcomes caused by medications, are common and difficult to detect. Electronic detection of ADEs is a promising method to identify ADEs. We performed this systematic review to characterize established electronic detection systems and their accuracy., METHODS: We identified studies evaluating electronic ADE detection from the MEDLINE and EMBASE databases. We included studies if they contained original data and involved detection of electronic triggers using information systems. We abstracted data regarding rule characteristics including type, accuracy, and rationale., RESULTS: Forty-eight studies met our inclusion criteria. Twenty-four (50%) studies reported rule accuracy but only 9 (18.8%) utilized a proper gold standard (chart review in all patients). Rule accuracy was variable and often poor (range of sensitivity: 40%-94%; specificity: 1.4%-89.8%; positive predictive value: 0.9%-64%). 5 (10.4%) studies derived or used detection rules that were defined by clinical need or the underlying ADE prevalence. Detection rules in 8 (16.7%) studies detected specific types of ADEs., CONCLUSION: Several factors led to inaccurate ADE detection algorithms, including immature underlying information systems, non-standard event definitions, and variable methods for detection rule validation. Few ADE detection algorithms considered clinical priorities. To enhance the utility of electronic detection systems, there is a need to systematically address these factors.

Tracking systems & Bar code

Dobson I, Doan Q, Hung G. **A systematic review of patient tracking systems for use in the pediatric emergency department**. The Journal of emergency medicine 2013;44(1):242-248.

Abstract: BACKGROUND: Patient safety is of great importance in the pediatric emergency department (PED). The combination of acutely and critically ill patients and high patient volumes creates a need for systems to support physicians in making accurate and timely diagnoses. Electronic patient tracking systems can potentially improve PED safety by reducing overcrowding and enhancing security., OBJECTIVES: To enhance our understanding of current electronic tracking technologies, how they are implemented in a clinical setting, and resulting effect on patient care outcomes including patient safety., METHODS: Nine databases were searched. Two independent reviewers identified articles that contained reference to patient tracking technologies in pediatrics or emergency medicine. Quantitative studies were assessed independently for methodological strength by two reviewers using an external assessment tool., RESULTS: Of 2292 initial articles, 22 were deemed relevant. Seventeen were qualitative, and the remaining five quantitative articles were assessed as being methodologically weak. Existing patient tracking systems in the ED included: infant monitoring/abduction prevention; barcode identification; radiofrequency identification (RFID)- or infrared (IR)-based patient tracking. Twenty articles supported the use of tracking technology to enhance patient safety or improve efficiency. One article failed to support the use of IR patient sensors due to study design flaws., CONCLUSIONS: Support exists for the use of barcode-, IR-, and RFID-based patient tracking systems to improve ED patient safety and efficiency. A lack of methodologically strong studies indicates a need for further evidence-based support for the implementation of patient tracking technology in a clinical or research setting.

Kullberg A, Larsen J, Sharp L. **'Why is there another person's name on my infusion bag?' Patient safety in chemotherapy care - a review of the literature**. European journal of oncology nursing : the official journal of European Oncology Nursing Society 2013;17(2):228-235.

Abstract: PURPOSE: Approximately 10% of all patients is in some way harmed by the health care system. Risk factors have been identified and patients with cancer are at high risk due to the seriousness of the disease, co-morbidity, often old age, high risk treatments such as chemo and radiotherapy. Therefore, a closer look on safety for patients undergoing chemotherapy is needed. The aim of this study was to identify and evaluate interventions for improved patient safety in chemotherapy care., METHOD: We undertook a review of the available evidence regarding interventions to improve patient safety in relation to chemotherapy care., RESULTS: We found 12 studies describing the following interventions; 1) Computerized Prescription Order Entry (CPOE), 2) Failure Mode and Effect Analysis (FMEA) and Lean Sigma, 3) Error reporting and surveillance systems, 4) Administration Checklist and 5) Education for nurses. Even if all five interventions showed positive effects in patient safety, the evidence level is rather weak due to design, sample size and the difficulties involved measuring patient safety issues., CONCLUSIONS: Three studies with fairly high evidence level showed that computerized chemotherapy prescriptions were significantly safer than manual prescriptions and could therefore be recommended. For the other remaining interventions, more research is needed to assess the effect on improved patient safety in chemotherapy care. There is a need for more rigorous studies with sophisticated design for generating evidence in the field.

Voshall B, Piscotty R, Lawrence J, Targosz M. **Barcode medication administration work-arounds: a systematic review and implications for nurse executives**. The Journal of nursing administration 2013;43(10):530-535.

Abstract: Safe medication administration is necessary to ensure quality healthcare. Barcode medication administration systems were developed to reduce drug administration errors and the related costs and improve patient safety. Work-arounds created by nurses in the execution of the required processes can lead to unintended consequences, including errors. This article provides a systematic review of the literature associated with barcoded medication administration and work-arounds and suggests interventions that should be adopted by nurse executives to ensure medication safety.

Snyder SR, Favoretto AM, Derzon JH, Christenson RH, Kahn SE, Shaw CS, et al. **Effectiveness of barcoding for reducing patient specimen and laboratory testing identification errors: A Laboratory Medicine Best Practices systematic review and meta-analysis**. Clin Biochem 2012;45(13-14):988-998.

Abstract: Objectives: This is the first systematic review of the effectiveness of barcoding practices for reducing patient specimen and laboratory testing identification errors. Design and methods: The CDC-funded Laboratory Medicine Best Practices Initiative systematic review methods for quality improvement practices were used. Results: A total of 17 observational studies reporting on barcoding systems are included in the body of evidence; 10 for patient specimens and 7 for point-of-care testing. All 17 studies favored barcoding, with meta-analysis mean odds ratios for barcoding systems of 4.39 (95% CI: 3.05-6.32) and for point-of-care testing of 5.93 (95% CI: 5.28-6.67). Conclusions: Barcoding is effective for reducing patient specimen and laboratory testing identification errors in diverse hospital settings and is recommended as an evidence-based "best practice." The overall strength of evidence rating is high and the effect size rating is substantial. Unpublished studies made an important contribution comprising almost half of the body of evidence. Disclaimer: The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention/the Agency for Toxic Substances and Disease Registry (CDC/ATSDR).

Elektroniske intervensjoner for å redusere feil og øke pasientsikkerhet

Maaskant JM, Vermeulen H, Apampa B, Fernando B, Ghaleb MA, Neubert A, et al. **Interventions for reducing medication errors in children in hospital**. The Cochrane database of systematic reviews 2015;3:CD006208.

Abstract: BACKGROUND: Many hospitalised patients are affected by medication errors (MEs) that may cause discomfort, harm and even death. Children are at especially high risk of harm as the result of MEs because such errors are potentially more hazardous to them than to adults. Until now, interventions to reduce MEs have led to only limited improvements., OBJECTIVES: To determine the effectiveness of interventions aimed at reducing MEs and related harm in hospitalised children., SEARCH METHODS: The Effective Practice and Organisation of Care Group (EPOC) Trials Search Co-ordinator searched the following sources for primary studies: The Cochrane Library, including the Cochrane Central Register of Controlled Trials (CENTRAL), the Economic Evaluation Database (EED) and the Health Technology Assessments (HTA) database; MEDLINE, EMBASE, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsycINFO, Proquest Dissertations & Theses, Web of Science (citation indexes and conference proceedings) and the EPOC Register of Studies. Related reviews were identified by searching the Cochrane Database of Systematic Reviews and the Database of Abstracts of Reviews of Effects (DARE). Review authors searched grey literature sources and trial registries. They handsearched selected journals, contacted researchers in the field and scanned reference lists of relevant reviews. They conducted searches in November 2013 and November 2014. They applied neither language nor date limits., SELECTION CRITERIA: Randomised controlled trials, controlled before-after studies and interrupted time series investigating interventions to improve medication safety in hospitalised children (< 18 years). Participants were healthcare professionals authorised to prescribe, dispense or administer medications. Outcome measures included MEs, (potential) patient harm, resource utilisation and unintended consequences of the interventions., DATA COLLECTION AND ANALYSIS: Two review authors independently selected studies, extracted data and assessed study quality using the EPOC data collection checklist. We evaluated the risk of bias of included studies and used the GRADE (Grades of Recommendation, Assessment, Development and Evaluation) approach to assess the quality of the body of evidence. We described results narratively and presented them using GRADE tables., MAIN RESULTS: We included seven studies describing five different interventions: participation of a clinical pharmacist in a clinical team (n = 2), introduction of a computerised physician order entry system (n = 2), implementation of a barcode medication administration system (n = 1), use of a structured prescribing form (n = 1) and implementation of a check and control checklist in combination with feedback (n = 1).Clinical and methodological heterogeneity between studies precluded meta-analyses. Although some interventions described in this review show a decrease in MEs, the results are not consistent, and none of the studies resulted in a significant reduction in patient harm. Based on the GRADE approach, the overall quality and strengfh of the evidence are low., AUTHORS' CONCLUSIONS: Current evidence on effective interventions to prevent MEs in a paediatric population in hospital is limited. Comparative studies with robust study designs are needed to investigate interventions including components that focus on specific paediatric safety issues.

Acheampong F, Anto BP, Koffuor GA. **Medication safety strategies in hospitals--a systematic review**. The International journal of risk & safety in medicine 2014;26(3):117-131.

Abstract: BACKGROUND: Medication safety is an essential component of patient safety in health care delivery. Providing strategies to effectively prevent medication errors and adverse drug events in hospitals has gained international recognition., OBJECTIVE: The aim of this paper was to review systematically the research literature on the various interventions for providing medication safety in hospitals., METHOD: Eight healthcare databases were searched for full research articles written in English. Reference lists of included studies were also searched. Research studies involving delivery of interventions in hospitals with the aim of preventing or reducing medication errors and adverse drug events were examined., RESULTS: Forty-two studies were selected. Most of the studies were before and after designs without comparative control groups. Forty studies identified interventions contributing to the prevention and reduction of medication errors. Six broad types of interventions were identified: computerized physician order entry with or without clinical decision support systems, automation, computer assisted, barcode technology, pharmacist role, training and system designs., CONCLUSION: Though studies have provided evidence for individual interventions, there are concerns about the extent of their effectiveness. This has implications for policy makers and clinicians to adopt multifaceted approach in providing medication safety in their hospitals.

Maaskant J, Vermeulen H, Apampa B, Fernando B, Ghaleb M, Neubert A, et al. **Interventions for reducing medication errors in children in hospital: A systematic review**. Arch Dis Child2014. p. A156.

Abstract: Background and aims Children are considered to be at high risk of experiencing harm due to medication erros (MEs). Hospitals implement various interventions to reduce MEs, but their effectiveness is unclear. Therefore, we performed a systematic review to identify evidence-based interventions to reduce MEs in hospitalised children. Methods We searched the following databases: CINAHL, CENTRAL, Dissertations and Theses Database, EMBASE, EPOC Group Specialised Register, MEDLINE, Nursing and Allied Health, PsycINFO, Web of Science, Cochrane Database of Systematic Reviews and DARE. Furthermore, we searched the grey literature, trial registries and the reference lists of all included studies. We included randomised controlled trials, controlled before-after studies and interrupted time series. The outcome measures included MEs, (potential) patient harm, resource utilisation and unintended consequences of the interventions. Two reviewers independently selected studies and assessed the studies quality. Results Seven studies were included describing five different interventions: clinical pharmacist (two studies), computerised physician order entry (two studies), barcode medication administration, a structured prescribing form, and a check and control checklist in combination with feedback. Most studies resulted in a reduction in MEs, but the benefits for the patients in terms of less harm were not conclusive. Clinical and methodological heterogeneity between the studies precluded meta-analyses. Conclusion The current evidence on effective interventions to prevent MEs in a paediatric population in hospital is limited. There is a need for comparative studies with robust study designs that investigate interventions including components that focus on specific paediatric safety issues.

Manias E, Kinney S, Cranswick N, Williams A, Borrott N. **Interventions to reduce medication errors in pediatric intensive care**. The Annals of pharmacotherapy 2014;48(10):1313-1331.

Abstract: OBJECTIVE: To systematically examine the research literature to identify which interventions reduce medication errors in pediatric intensive care units., DATA SOURCES: Databases were searched from inception to April 2014., STUDY SELECTION AND DATA EXTRACTION: Studies were included if they involved the conduct of an intervention with the intent of reducing medication errors., DATA SYNTHESIS: In all, 34 relevant articles were identified. Apart from 1 study, all involved single-arm, before-and-after designs without a comparative, concurrent control group. A total of 6 types of interventions were utilized: computerized physician order entry (CPOE), intravenous systems (ISs), modes of education (MEs), protocols and guidelines (PGs), pharmacist involvement (PI), and support systems for clinical decision making (SSCDs). Statistically significant reductions in medication errors were achieved in 7/8 studies for CPOE, 2/5 studies for ISs, 9/11 studies for MEs, 1/2 studies for PGs, 2/3 studies for PI, and 3/5 studies for SSCDs. The test for subgroup differences showed that there was no statistically significant difference among the 6 subgroups of interventions, chi(2)(5) = 1.88, P = 0.87. The following risk ratio results for meta-analysis were obtained: CPOE: 0.47 (95% CI = 0.28, 0.79); IS: 0.37 (95% CI = 0.19, 0.73); ME: 0.36 (95% CI = 0.22, 0.58); PG: 0.82 (95% CI = 0.21, 3.25); PI: 0.39 (95% CI = 0.10, 1.51), and SSCD: 0.49 (95% CI = 0.23, 1.03)., CONCLUSIONS: Available evidence suggests some aspects of CPOE with decision support, ME, and IS may help in reducing medication errors. Good quality, prospective, observational studies are needed for institutions to determine the most effective interventions.

Rinke ML, Bundy DG, Velasquez CA, Rao S, Zerhouni Y, Lobner K, et al. **Interventions to reduce pediatric medication errors: a systematic review**. Pediatrics 2014;134(2):338-360.

Abstract: BACKGROUND AND OBJECTIVE: Medication errors cause appreciable morbidity and mortality in children. The objective was to determine the effectiveness of interventions to reduce pediatric medication errors, identify gaps in the literature, and perform meta-analyses on comparable studies., METHODS: Relevant studies were identified from searches of PubMed, Embase, Scopus, Web of Science, the Cochrane Library, and the Cumulative Index to Nursing Allied Health Literature and previous systematic reviews. Inclusion criteria were peer-reviewed original data in any language testing an intervention to reduce medication errors in children. Abstract and full-text article review were conducted by 2 independent authors with sequential data extraction., RESULTS: A total of 274 full-text articles

were reviewed and 63 were included. Only 1% of studies were conducted at community hospitals, 11% were conducted in ambulatory populations, 10% reported preventable adverse drug events, 10% examined administering errors, 3% examined dispensing errors, and none reported cost-effectiveness data, suggesting persistent research gaps. Variation existed in the methods, definitions, outcomes, and rate denominators for all studies; and many showed an appreciable risk of bias. Although 26 studies (41%) involved computerized provider order entry, a meta-analysis was not performed because of methodologic heterogeneity. Studies of computerized provider order entry with clinical decision support compared with studies without clinical decision support reported a 36% to 87% reduction in prescribing errors; studies of preprinted order sheets revealed a 27% to 82% reduction in prescribing errors., CONCLUSIONS: Pediatric medication errors can be reduced, although our understanding of optimal interventions remains hampered. Research should focus on understudied areas, use standardized definitions and outcomes, and evaluate cost-effectiveness.

Carling CLL, Kirkehei I, Dalsbo TK, Paulsen E. **Risks to patient safety associated with implementation of electronic applications for medication management in ambulatory care--a systematic review**. BMC Med Inform Decis Mak 2013;13:133.

Abstract: BACKGROUND: The objective was to find evidence to substantiate assertions that electronic applications for medication management in ambulatory care (electronic prescribing, clinical decision support (CDSS), electronic health record, and computer generated paper prescriptions), while intended to reduce prescribing errors, can themselves result in errors that might harm patients or increase risks to patient safety., METHODS: Because a scoping search for adverse events in randomized controlled trials (RCTs) yielded few relevant results, we systematically searched nine databases, including MEDLINE, EMBASE, and The Cochrane Database of Systematic Reviews for systematic reviews and studies of a wide variety of designs that reported on implementation of the interventions. Studies that had safety and adverse events as outcomes, monitored for them, reported anecdotally adverse events or other events that might indicate a threat to patient safety were included., RESULTS: We found no systematic reviews that examined adverse events or patient harm caused by organizational interventions. Of the 4056 titles and abstracts screened, 176 full-text articles were assessed for inclusion. Sixty-one studies with appropriate interventions, settings and participants but without patient safety, adverse event outcomes or monitoring for risks were excluded, along with 77 other non-eligible studies. Eighteen randomized controlled trials (RCTs), 5 non-randomized controlled trials (non-R,CTs) and 15 observational studies were included. The most common electronic intervention studied was CDSS and the most frequent clinical area was cardio-vascular, including anti-coagulants. No RCTS or non-R,CTS reported adverse event. Adverse events reported in observational studies occurred less frequently after implementation of CDSS. One RCT and one observational study reported an increase in problematic prescriptions with electronic prescribing, CONCLUSIONS: The safety implications of electronic medication management in ambulatory care have not been established with results from studies included in this systematic review. Only a minority of studies that investigated these interventions included threats to patients' safety as outcomes or monitored for adverse events. It is therefore not surprising that we found little evidence to substantiate fears of new risks to patient safety with their implementation. More research is needed to focus on the draw-backs and negative outcomes that implementation of these interventions might introduce.

Clyne B, Bradley MC, Hughes C, Fahey T, Lapane KL. **Electronic prescribing and other forms of technology to reduce inappropriate medication use and polypharmacy in older people: a review of current evidence**. Clin Geriatr Med 2012;28(2):301-322.

Abstract: This review provided an overview of the current evidence in relation to the use of e-prescribing and other forms of technology, such as CDSS, to reduce inappropriate prescribing in older people. The evidence indicates that various types of e-prescribing and CDSS interventions have the potential to reduce inappropriate prescribing and polypharmacy in older people, but the magnitude of their effect varies according to study design and setting. There was significant heterogeneity in the studies reported in terms of study designs, intervention design, patient settings, and outcome measures with patient outcomes seldom reported. Widespread diffusion of these interventions has not occurred in any of the health care settings examined. Overall, health care providers report being satisfied with e-prescribing systems and see the systems as having a positive impact on the safety of their prescribing practices, yet the problem of overriding or ignoring alerts persists. The problem of large

numbers of inaccurate and insignificant alerts and this issue, along with the other barriers that have been identified, warrant further investigation.

Manias E, Williams A, Liew D. **Interventions to reduce medication errors in adult intensive care: a systematic review**. Br J Clin Pharmacol 2012;74(3):411-423.

Abstract: Critically ill patients need life saving treatments and are often exposed to medications requiring careful titration. The aim of this paper was to review systematically the research literature on the efficacy of interventions in reducing medication errors in intensive care. A search was conducted of PubMed, CINAHL EMBASE, Journals@Ovid, International Pharmaceutical Abstract Series via Ovid, ScienceDirect, Scopus, Web of Science, PsycInfo and The Cochrane Collaboration from inception to October 2011. Research studies involving delivery of an intervention in intensive care for adult patients with the aim of reducing medication errors were examined. Eight types of interventions were identified: computerized physician order entry (CPOE), changes in work schedules (CWS), intravenous systems (IS), modes of education (ME), medication reconciliation (MR), pharmacist involvement (PI), protocols and guidelines (PG) and support systems for clinical decision making (SSCD). Sixteen out of the 24 studies showed reduced medication error rates. Four intervention types demonstrated reduced medication errors post-intervention: CWS, ME, MR and PG. It is not possible to promote any interventions as positive models for reducing medication errors. Insufficient research was undertaken with any particular type of intervention, and there were concerns regarding the level of evidence and quality of research. Most studies involved single arm, before and after designs without a comparative control group. Future researchers should address gaps identified in single faceted interventions and gather data on multi-faceted interventions using high quality research designs. The findings demonstrate implications for policy makers and clinicians in adopting resource intensive processes and technologies, which offer little evidence to support their efficacy.

Generelt om helseinformasjonssystemer

Cheung A, Van Velden FHP, Lagerburg V, Minderman N. **The organizational and clinical impact of integrating bedside equipment to an information system: A systematic literature review of patient data management systems (PDMS)**. Int J Med Inform 2015;84(3):155-165.

Abstract: Objective: The introduction of an information system integrated to bedside equipment requires significant financial and resource investment; therefore understanding the potential impact is beneficial for decision-makers. However, no systematic literature reviews (SLRs) focus on this topic. This SLR aims to gather evidence on the impact of the aforementioned system, also known as a patient data management system (PDMS) on both organizational and clinical outcomes. Materials and Methods A literature search was performed using the databases Medline/PubMed and CINHAL for English articles published between January 2000 and December 2012. A quality assessment was performed on articles deemed relevant for the SLR. Results Eighteen articles were included in the SLR. Sixteen articles investigated the impact of a PDMS on the organizational outcomes, comprising descriptive, quantitative and qualitative studies. A PDMS was found to reduce the charting time, increase the time spent on direct patient care and reduce the occurrence of errors. Only two articles investigated the clinical impact of a PDMS. Both reported an improvement in clinical outcomes when a PDMS was integrated with a clinical decision support system (CDSS). Conclusions A PDMS has shown to offer many advantages in both the efficiency and the quality of care delivered to the patient. In addition, a PDMS integrated to a CDSS may improve clinical outcomes, although further studies are required for validation.

Jones SS, Rudin RS, Perry T, Shekelle PG. **Health information technology: an updated systematic review with a focus on meaningful use**. Ann Intern Med 2014;160(1):48-54.

Abstract: BACKGROUND: Incentives offered by the U.S. government have spurred marked increases in use of health information technology (IT)., PURPOSE: To update previous reviews and examine recent evidence that relates health IT functionalities prescribed in meaningful use regulations to key aspects of health care., DATA SOURCES: English-language articles in PubMed from January 2010 to August 2013., STUDY SELECTION: 236 studies, including pre-post and time-series designs and clinical trials that related the use of

health IT to quality, safety, or efficiency., DATA EXTRACTION: Two independent reviewers extracted data on functionality, study outcomes, and context., DATA SYNTHESIS: Fifty-seven percent of the 236 studies evaluated clinical decision support and computerized provider order entry, whereas other meaningful use functionalities were rarely evaluated. Fifty-six percent of studies reported uniformly positive results, and an additional 21% reported mixed-positive effects. Reporting of context and implementation details was poor, and 61% of studies did not report any contextual details beyond basic information., LIMITATION: Potential for publication bias, and evaluated health IT systems and outcomes were heterogeneous and incompletely described., CONCLUSION: Strong evidence supports the use of clinical decision support and computerized provider order entry. However, insufficient reporting of implementation and context of use makes it impossible to determine why some health IT implementations are successful and others are not. The most important improvement that can be made in health IT evaluations is increased reporting of the effects of implementation and context., PRIMARY FUNDING SOURCE: Office of the National Coordinator.

Minshall S. **A review of healthcare information system usability & safety**. Stud Health Technol Inform 2013;183:151-156.

Abstract: Healthcare information systems have been designed to increase the efficiency and safety of healthcare processes. Systems such as electronic health records and pervasive computing devices have been shown to improve the safety of healthcare. However, increasing research has indicated that the design of such systems, in particular the user interface, may be related to increased incidence of other types of error. In this review, the relationship between human factors and usability will be considered in the context of designing safe and effective healthcare applications, with a focus on hand-held computing devices. Medline was searched for the specific terms listed below and restricted to the date ranges 2006-01-01 through to 2011-03-03: (error AND technology AND human factors); (error AND (CPOE OR (Computerized AND provider AND order AND entry))); (Technology AND Induced AND Error). The returned list of papers was screened by examining titles and abstracts to select candidate papers for further review. The initial search yield was 239 papers. On reviewing the title and abstract, 186 were rejected and 51 papers remained for analysis. New technology, such as CPOE, offers improvements over traditional paper tools and it is shown to have a positive effect on patient safety. New technology also creates the opportunity for new errors to occur and lead to the coining of the term "technology-induced error". The magnitude of the usability-testing needs is larger than it may seem.

McKibbon KA, Lokker C, Handler SM, Dolovich LR, Holbrook AM, O'Reilly D, et al. **The effectiveness of integrated health information technologies across the phases of medication management: a systematic review of randomized controlled trials**. Journal of the American Medical Informatics Association : JAMIA 2012;19(1):22-30.

Abstract: OBJECTIVE: The US Agency for Healthcare Research and Quality funded an evidence report to address seven questions on multiple aspects of the effectiveness of medication management information technology (MMIT) and its components (prescribing, order communication, dispensing, administering, and monitoring)., MATERIALS AND METHODS: Medline and 11 other databases without language or date limitations to mid-2010. Randomized controlled trials (RCTs) assessing integrated MMIT were selected by two independent reviewers. Reviewers assessed study quality and extracted data. Senior staff checked accuracy., RESULTS: Most of the 87 RCTs focused on clinical decision support and computerized provider order entry systems, were performed in hospitals and clinics, included primarily physicians and sometimes nurses but not other health professionals, and studied process changes related to prescribing and monitoring medication. Processes of care improved for prescribing and monitoring mostly in hospital settings, but the few studies measuring clinical outcomes showed small or no improvements. Studies were performed most frequently in the USA (n=63), Europe (n=16), and Canada (n=6)., DISCUSSION: Many studies had limited description of systems, installations, institutions, and targets of the intervention. Problems with methods and analyses were also found. Few studies addressed order communication, dispensing, or administering, non-physician prescribers or pharmacists and their MMIT tools, or patients and caregivers. Other study methods are also needed to completely understand the effects of MMIT., CONCLUSIONS: Almost half of MMIT interventions improved the process of care, but few studies measured clinical outcomes. This large body of literature, although instructive, is not uniformly distributed across settings, people, medication phases, or outcomes.

Rahadhan P, Poon SK, Land L. **Understanding unintended consequences for EMR: a literature review**. Stud Health Technol Inform 2012;178:192-198.

Abstract: While Electronic Medical Records (EMR) have been hailed as an important step for advancing healthcare, a number of studies have noted that its introduction also brings unintended consequences to healthcare organisations. This means that introducing EMR to key stakeholders such as clinicians, healthcare administrators, as well as to the overall healthcare organisations, may not be as straightforward as we have hoped for. There has been some empirical work and systematic reviews specifically addressing the unintended consequences for EMR. Given the complexity of these issues, continued effort to investigate them is critical. This paper first proposes an integration and systematisation of the existing literature on the unintended consequences of EMR (including its various definitions and classifications), and then provides insights for dealing with these issues, including mitigation strategies for addressing these issues.

Black AD, Car J, Pagliari C, Anandan C, Cresswell K, Bokun T, et al. **The impact of eHealth on the quality and safety of health care: a systematic overview**. PLoS Med 2011;8(1):e1000387.

Abstract: BACKGROUND: There is considerable international interest in exploiting the potential of digital solutions to enhance the quality and safety of health care. Implementations of transformative eHealth technologies are underway globally, often at very considerable cost. In order to assess the impact of eHealth solutions on the quality and safety of health care, and to inform policy decisions on eHealth deployments, we undertook a systematic review of systematic reviews assessing the effectiveness and consequences of various eHealth technologies on the quality and safety of care., METHODS AND FINDINGS: We developed novel search strategies, conceptual maps of health care quality, safety, and eHealth interventions, and then systematically identified, scrutinised, and synthesised the systematic review literature. Major biomedical databases were searched to identify systematic reviews published between 1997 and 2010. Related theoretical, methodological, and technical material was also reviewed. We identified 53 systematic reviews that focused on assessing the impact of eHealth interventions on the quality and/or safety of health care and 55 supplementary systematic reviews providing relevant supportive information. This systematic review literature was found to be generally of substandard quality with regards to methodology, reporting, and utility. We thematically categorised eHealth technologies into three main areas: (1) storing, managing, and transmission of data; (2) clinical decision support; and (3) facilitating care from a distance. We found that despite support from policymakers, there was relatively little empirical evidence to substantiate many of the claims made in relation to these technologies. Whether the success of those relatively few solutions identified to improve quality and safety would continue if these were deployed beyond the contexts in which they were originally developed, has yet to be established. Importantly, best practice guidelines in effective development and deployment strategies are lacking., CONCLUSIONS: There is a large gap between the postulated and empirically demonstrated benefits of eHealth technologies. In addition, there is a lack of robust research on the risks of implementing these technologies and their cost-effectiveness has yet to be demonstrated, despite being frequently promoted by policymakers and "techno-enthusiasts" as if this was a given. In the light of the paucity of evidence in relation to improvements in patient outcomes, as well as the lack of evidence on their cost-effectiveness, it is vital that future eHealth technologies are evaluated against a comprehensive set of measures, ideally throughout all stages of the technology's life cycle. Such evaluation should be characterised by careful attention to socio-technical factors to maximise the likelihood of successful implementation and adoption.

McKibbon KA, Lokker C, Handler SM, Dolovich LR, Holbrook AM, O'Reilly D, et al. **Enabling medication management through health information technology (Health IT)**. Evidence report/technology assessment 2011 (201):1-951.

Abstract: OBJECTIVES: The objective of the report was to review the evidence on the impact of health information technology (IT) on all phases of the medication management process (prescribing and ordering, order communication, dispensing, administration and monitoring as well as education and reconciliation), to identify the gaps in the literature and to make recommendations for future research., DATA SOURCES: We searched peer-reviewed electronic databases, grey literature, and performed hand searches. Databases searched included MEDLINE, Embase, CINAHL (Cumulated Index to Nursing and Allied

Health Literature), Cochrane Database of Systematic Reviews, International Pharmaceutical Abstracts, Compendex, Inspec (which includes IEEE Xplore), Library and Information Science Abstracts, E-Prints in Library and Information Science, PsycINFO, Sociological Abstracts, and Business Source Complete. Grey literature searching involved Internet searching, reviewing relevant Web sites, and searching electronic databases of grey literatures. AHRQ also provided all references in their e-Prescribing, bar coding, and CPOE knowledge libraries., METHODS: Paired reviewers looked at citations to identify studies on a range of health IT used to assist in the medication management process (MMIT) during multiple levels of screening (titles and abstracts, full text and final review for assignment of questions and data abstrction). Randomized controlled trials and cohort, case-control, and case series studies were independently assessed for quality. All data were abstracted by one reviewer and examined by one of two different reviewers with content and methods expertise., RESULTS: 40,582 articles were retrieved. After duplicates were removed, 32,785 articles were screened at the title and abstract phase. 4,578 full text articles were assessed and 789 articles were included in the final report. Of these, 361 met only content criteria and were listed without further abstraction. The final report included data from 428 articles across the seven key questions. Study quality varied according to phase of medication management. Substantially more studies, and studies with stronger comparative methods, evaluated prescribing and monitoring. Clinical decision support systems (CDSS) and computerized provider order entry (CPOE) systems were studied more than any other application of MMIT. Physicians were more often the subject of evaluation than other participants. Other health care professionals, patients, and families are important but not studied as thoroughly as physicians. These nonphysicians groups often value different aspects of MMIT, have diverse needs, and use systems differently. Hospitals and ambulatory clinics were well-represented in the literature with less emphasis placed on long-term care facilities, communities, homes, and nonhospital pharmacies. Most studies evaluated changes in process and outcomes of use, usability, and knowledge, skills, and attitudes. Most showed moderate to substantial improvement with implementation of MMIT. Economics studies and those with clinical outcomes were less frequently studied. Those articles that did address economics and clinical outcomes often showed equivocal findings on the effectiveness and cost-effectiveness of MMIT systems. Qualitative studies provided evidence of strong perceptions, both positive and negative, of the effects of MMIT and unintended consequences. We found little data on the effects of forms of medications, conformity, standards, and open source status. Much descriptive literature discusses implementation issues but little strong evidence exists. Interest is strong in MMIT and more groups and institutions will implement systems in the next decades, especially with the Federal Government's push toward more health IT to support better and more cost-effective health care., CONCLUSIONS: MMIT is well-studied, although on closer examination of the literature the evidence is not uniform across phases of medication management, groups of people involved, or types of MMIT. MMIT holds the promise of i proved processes; clinical and economics studies and the understanding of sustainability issues are lacking.

Wulff K, Cummings GG, Marck P, Yurtseven O. **Medication administration technologies and patient safety: a mixed-method systematic review**. J Adv Nurs 2011;67(10):2080-2095.

Abstract: BACKGROUND: Healthcare leaders need evidence-based information on nursing medication administration technologies to guide the design of improvements to patient safety., AIM: The aim of this study was to evaluate the research evidence on relationships between the use of medication administration technologies and incidence of medication administration incidents and preventable adverse drug events to inform decision-making about existing technology options., DATA SOURCES: Thirteen electronic databases and seven relevant patient safety websites were searched for the years 1980-2009., REVIEW METHODS: A mixed-method systematic literature review of research on medication administration technologies and associated links to patient safety, operationalized as medication administration incidents and preventable adverse drug events, was conducted., RESULTS: Twelve studies (two qualitative, five pre- and postinterventions and five correlational) met the inclusion criteria. All were assessed as medium quality with low generalizability of study findings. Only two studies sampled more than one hospital and none of the studies was driven by an explicit theoretical framework. The studies included in this review are generally positive towards medication administration technologies and their potential benefits, yet the level of evidence overall is equivocal. The majority of studies pointed to the development of workarounds by nurses following medication administration technology implementation

that could compromise patient safety., CONCLUSION: More theoretically driven research is needed to determine which medication administration technologies should be implemented in what ways to most effectively reduce medication administration incidents and preventable adverse drug events and minimize the development of potentially unsafe workarounds. Further evidence is required to accurately assess the actual contribution of medication administration technologies for improving patient safety.

Fischer SH, Tjia J, Field TS. **Impact of health information technology interventions to improve medication laboratory monitoring for ambulatory patients: a systematic review**. Journal of the American Medical Informatics Association : JAMIA 2010;17(6):631-636.

Abstract: Medication errors are a major source of morbidity and mortality. Inadequate laboratory monitoring of high-risk medications after initial prescription is a medical error that contributes to preventable adverse drug events. Health information technology (HIT)-based clinical decision support may improve patient safety by improving the laboratory monitoring of high-risk medications, but the effectiveness of such interventions is unclear. Therefore, the authors conducted a systematic review to identify studies that evaluate the independent effect of HIT interventions on improving laboratory monitoring for high-risk medications in the ambulatory setting using a Medline search from January 1, 1980 through January 1, 2009 and a manual review of relevant bibliographies. All anticoagulation monitoring studies were excluded. Eight articles met the inclusion criteria, including six randomized controlled trials and two pre-post intervention studies. Six of the studies were conducted in two large, integrated healthcare delivery systems in the USA. Overall, five of the eight studies reported statistically significant, but small, improvements in laboratory monitoring; only half of the randomized controlled trials reported statistically significant improvements. Studies that found no improvement were more likely to have used analytic strategies that addressed clustering and confounding. Whether HIT improves laboratory monitoring of certain high-risk medications for ambulatory patients remains unclear, and further research is needed to clarify this important question.

Vedlegg 3 Primærstudier

Beslutningsstøtte (decision support, reminders & order set)
RCT

Beeler PE, Eschmann E, Schumacher A, Studt JD, Amann-Vesti B, Blaser J. **Impact of electronic reminders on venous thromboprophylaxis after admissions and transfers**. Journal of the American Medical Informatics Association : JAMIA 2014;21(e2):e297-303.

Abstract: OBJECTIVE: Clinical decision support has the potential to improve prevention of venous thromboembolism (VTE). The purpose of this prospective study was to analyze the effect of electronic reminders on thromboprophylaxis rates in wards to which patients were admitted and transferred. The latter was of particular interest since patient handoffs are considered to be critical safety issues., METHODS: The trial involved two study periods in the six departments of a university hospital, three of which were randomly assigned to the intervention group displaying reminders during the second period. At 6 h after admission or transfer, the algorithm checked for prophylaxis orders within 0-30 h of the patient's arrival, increasing the specificity of the displayed reminders., RESULTS: The significant impact of the reminders could be seen by prophylaxis orders placed 6-24 h after admission (increasing from 8.6% (223/2579) to 12% (307/2555); p<0.0001) and transfer (increasing from 2.4% (39/1616) to 3.7% (63/1682); p=0.034). In admission wards, the rate of thromboprophylaxis increased from 62.4% to 67.7% (p<0.0001), and in transfer wards it increased from 80.2% to 84.3% (p=0.0022). Overall, the rate of prophylaxis significantly increased in the intervention group from 69.2% to 74.3% (p<0.0001). No significant changes were observed in the control group. Postponing prophylaxis checks to 6 h after admissions and transfers reduced the number of reminders by 62% and thereby minimized the risk of alert fatigue., CONCLUSIONS: The reminders improved awareness of VTE prevention in both admission and transfer wards. This approach may contribute to better quality of care and safer patient handoffs.

Dexter PR, Perkins S, Overhage JM, Maharry K, Kohler RB, McDonald CJ. **A computerized reminder system to increase the use of preventive care for hospitalized patients**. The New England journal of medicine 2001;345(13):965-970.

Abstract: BACKGROUND: Although they are effective in outpatient settings, computerized reminders have not been proved to increase preventive care in inpatient settings., METHODS: We conducted a randomized, controlled trial to determine the effects of computerized reminders on the rates at which four preventive therapies were ordered for inpatients. During an 18-month study period, a computerized system processed on-line information for all 6371 patients admitted to a general-medicine service (for a total of 10,065 hospitalizations), generating preventive care reminders as appropriate. Physicians who were in the intervention group viewed these reminders when they were using a computerized order-entry system for inpatients., RESULTS: The reminder system identified 3416 patients (53.6 percent) as eligible for preventive measures that had not been ordered by the admitting physician. For patients with at least one indication, computerized reminders resulted in higher adjusted ordering rates for pneumococcal vaccination (35.8 percent of the patients in the intervention group vs. 0.8 percent of those in the control group, P<0.001), influenza vaccination (51.4 percent vs. 1.0 percent, P< 0.001), prophylactic heparin (32.2 percent vs. 18.9 percent, P<0.001), and prophylactic aspirin at discharge (36.4 percent vs. 27.6 percent, P<0.001)., CONCLUSIONS: A majority of hospitalized patients in this study were eligible for preventive

measures, and computerized reminders significantly increased the rate of delivery of such therapies.

Field TS, Rochon P, Lee M, Gavendo L, Baril JL, Gurwitz JH. **Computerized clinical decision support during medication ordering for long-term care residents with renal insufficiency**. Journal of the American Medical Informatics Association : JAMIA 2009;16(4):480-485.

Abstract: UNLABELLED: OBJECTIVE To determine whether a computerized clinical decision support system providing patient-specific recommendations in real-time improves the quality of prescribing for long-term care residents with renal insufficiency. DESIGN Randomized trial within the long-stay units of a large long-term care facility. Randomization was within blocks by unit type. Alerts related to medication prescribing for residents with renal insufficiency were displayed to prescribers in the intervention units and hidden but tracked in control units. Measurement The proportions of final drug orders that were appropriate were compared between intervention and control units within alert categories: (1) recommended medication doses; (2) recommended administration frequencies; (3) recommendations to avoid the drug; (4) warnings of missing information. RESULTS The rates of alerts were nearly equal in the intervention and control units: 2.5 per 1,000 resident days in the intervention units and 2.4 in the control units. The proportions of dose alerts for which the final drug orders were appropriate were similar between the intervention and control units (relative risk 0.95, 95% confidence interval 0.83, 1.1) for the remaining alert categories significantly higher proportions of final drug orders were appropriate in the intervention units: relative risk 2.4 for maximum frequency (1.4, 4.4); 2.6 for drugs that should be avoided (1.4, 5.0); and 1.8 for alerts to acquire missing information (1.1, 3.4). Overall, final drug orders were appropriate significantly more often in the intervention units-relative risk 1.2 (1.0, 1.4). CONCLUSIONS Clinical decision support for physicians prescribing medications for long-term care residents with renal insufficiency can improve the quality of prescribing decisions., TRIAL REGISTRATION: http://clinicaltrials.gov Identifier: NCT00599209.

Gurwitz JH, Field TS, Rochon P, Judge J, Harrold LR, Bell CM, et al. **Effect of computerized provider order entry with clinical decision support on adverse drug events in the long-term care setting**. J Am Geriatr Soc 2008;56(12):2225-2233.

Abstract: OBJECTIVES: To evaluate the efficacy of computerized provider order entry with clinical decision support for preventing adverse drug events in long-term care., DESIGN: Cluster-randomized controlled trial., SETTING: Two large long-term care facilities., PATIENTS: One thousand one hundred eighteen long-term care residents of 29 resident care units., INTERVENTION: The 29 resident care units, each with computerized provider order entry, were randomized to having a clinical decision support system (intervention units) or not (control units)., MEASUREMENTS: The number of adverse drug events, severity of events, and whether the events were preventable., RESULTS: Within intervention units, 411 adverse drug events occurred over 3,803 resident-months of observation time; 152 (37.0%) were deemed preventable. Within control units, there were 340 adverse drug events over 3,257 resident-months of observation time; 126 (37.1%) were characterized as preventable. There were 10.8 adverse drug events per 100 resident-months and 4.0 preventable events per 100 resident-months on intervention units. There were 10.4 adverse drug events per 100 resident-months and 3.9 preventable events per 100 resident-months on control units. Comparing intervention and control units, the adjusted rate ratios were 1.06 (95% confidence interval (CI)=0.92-1.23) for all adverse drug events and 1.02 (95% CI=0.81-1.30) for preventable adverse drug events., CONCLUSION: Computerized provider order entry with decision support did not reduce the adverse drug event rate or preventable adverse drug event rate in the long-term care setting. Alert burden, limited scope of the alerts, and a need to more fully integrate clinical and laboratory information may have affected efficacy.

Murray MD, Loos B, Tu W, Eckert GJ, Zhou XH, Tierney WM. **Work patterns of ambulatory care pharmacists with access to electronic guideline-based treatment suggestions**. American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists 1999;56(3):225-232.

Abstract: The effects of the electronic display of guideline-based, patient-specific treatment suggestions on pharmacist work patterns were studied. A total of 28 pharmacists at a hospital-based ambulatory care pharmacy were randomly assigned to intervention and control groups. The intervention group had access to electronic treatment suggestions for heart failure, ischemic heart disease, reactive airways disease, and uncomplicated hypertension,

while the control group did not. Starting 9 and 19 months after the initial display of treatment suggestions, all pharmacists recorded the time they spent on a variety of activities, the purpose of each activity, and persons contacted during the activity; these observations were recorded in response to a pager-like device that randomly buzzed four times an hour. A total of 11,102 observations were recorded. Pharmacists in the intervention group spent significantly more of their time discussing information, advising and informing, and solving problems than pharmacists in the control group but significantly less of their time checking and filling prescriptions. Pharmacists in both groups completed a majority of their work alone, but pharmacists in the intervention group worked significantly less by themselves and significantly more with other pharmacy personnel, patients, and physicians and nurses than control-group pharmacists. The delivery of patient-specific information to pharmacists at the time of dispensing had a significant positive impact on pharmacist work patterns.

Schnipper JL, Liang CL, Ndumele CD, Pendergrass ML. **Effects of a computerized order set on the inpatient management of hyperglycemia: a cluster-randomized controlled trial**. Endocrine practice : official journal of the American College of Endocrinology and the American Association of Clinical Endocrinologists 2010;16(2):209-218.

Abstract: OBJECTIVE: To determine the effects of a computerized order set on the inpatient management of diabetes and hyperglycemia., METHODS: We conducted a cluster-randomized controlled trial on the general medical service of an academic medical center staffed by residents and hospitalists. Consecutively enrolled patients with diabetes mellitus or inpatient hyperglycemia were randomized on the basis of their medical team to usual care (control group) or an admission order set built into the hospital's computer provider order entry (CPOE) system (intervention group). All teams received a detailed subcutaneous insulin protocol and case-based education. The primary outcome was the mean percent of glucose readings per patient between 60 and 180 mg/dL., RESULTS: Between April 5 and June 22, 2006, we identified 179 eligible study subjects. The mean percent of glucose readings per patient between 60 and 180 mg/dL was 75% in the intervention group and 71% in the usual care group (adjusted relative risk, 1.36; 95% confidence interval, 1.03 to 1.80). In comparison with usual care, the intervention group also had a lower patient-day weighted mean glucose (148 mg/dL versus 158 mg/dL, P = .04), less use of sliding-scale insulin by itself (25% versus 58%, P = .01), and no significant difference in the rate of severe hypoglycemia (glucose <40 mg/dL; 0.5% versus 0.3% of patient-days, P = .58)., CONCLUSION: The use of an order set built into a hospital's CPOE system led to improvements in glycemic control and insulin ordering without causing a significant increase in hypoglycemia. Other institutions with CPOE should consider adopting similar order sets as part of a comprehensive inpatient glycemic management program.

Terrell KM, Perkins AJ, Dexter PR, Hui SL, Callahan CM, Miller DK. **Computerized decision support to reduce potentially inappropriate prescribing to older emergency department patients: a randomized, controlled trial**. J Am Geriatr Soc 2009;57(8):1388-1394.

Abstract: OBJECTIVES: To evaluate the effectiveness of computer-assisted decision support in reducing potentially inappropriate prescribing to older adults., DESIGN: Randomized, controlled trial., SETTING: An academic emergency department (ED) in Indianapolis, Indiana, where computerized physician order entry was used to write all medication prescriptions., PARTICIPANTS: Sixty-three emergency physicians were randomized to the intervention (32 physicians) or control (31 physicians) group., INTERVENTION: Decision support that advised against use of nine potentially inappropriate medications and recommended safer substitute therapies., MEASUREMENTS: The primary outcome was the proportion of ED visits by seniors that resulted in one or more prescriptions for an inappropriate medication. The main secondary outcomes were the proportions of medications prescribed that were inappropriate and intervention physicians' reasons for rejecting the decision support., RESULTS: The average age of the patients was 74, two-thirds were female, and just over half were African American. Decision support was provided 114 times to intervention physicians, who accepted 49 (43%) of the recommendations. Intervention physicians prescribed one or more inappropriate medications during 2.6% of ED visits by seniors, compared with 3.9% of visits managed by control physicians (P=.02; odds ratio=0.55, 95% confidence interval=0.34-0.89). The proportion of all prescribed medications that were inappropriate significantly decreased from 5.4% to 3.4%. The most common reason for rejecting decision support was that the patient had no prior problems with the medication., CONCLU-

SION: Computerized physician order entry with decision support significantly reduced prescribing of potentially inappropriate medications for seniors. This approach might be used in other efforts to improve ED care., TRIAL REGISTRATION: Clinical trials.gov Identifier: NCT00297869.

Terrell KM, Perkins AJ, Hui SL, Callahan CM, Dexter PR, Miller DK. **Computerized decision support for medication dosing in renal insufficiency: a randomized, controlled trial**. Ann Emerg Med 2010;56(6):623-629.

Abstract: STUDY OBJECTIVE: Emergency physicians prescribe several discharge medications that require dosage adjustment for patients with renal disease. The hypothesis for this research was that decision support in a computerized physician order entry system would reduce the rate of excessive medication dosing for patients with renal impairment., METHODS: This was a randomized, controlled trial in an academic emergency department (ED), in which computerized physician order entry was used to write all prescriptions for patients being discharged from the ED. The sample included 42 physicians who were randomized to the intervention (21 physicians) or control (21 physicians) group. The intervention was decision support that provided dosing recommendations for targeted medications for patients aged 18 years and older when the patient's estimated creatinine clearance level was below the threshold for dosage adjustment. The primary outcome was the proportion of targeted medications that were excessively dosed., RESULTS: For 2,783 (46%) of the 6,015 patient visits, the decision support had sufficient information to estimate the patient's creatinine clearance level. The average age of these patients was 46 years, 1,768 (64%) were women, and 1,523 (55%) were black. Decision support was provided 73 times to physicians in the intervention group, who excessively dosed 31 (43%) prescriptions. In comparison, control physicians excessively dosed a significantly larger proportion of medications: 34 of 46, 74% (effect size=31%; 95% confidence interval 14% to 49%; P=.001)., CONCLUSION: Emergency physicians often prescribed excessive doses of medications that require dosage adjustment for renal impairment. Computerized physician order entry with decision support significantly reduced excessive dosing of targeted medications.

ITS

Elsaid K, Truong T, Monckeberg M, McCarthy H, Butera J, Collins C. **Impact of electronic chemotherapy order forms on prescribing errors at an urban medical center: results from an interrupted time-series analysis**. International journal for quality in health care: journal of the International Society for Quality in Health Care / ISQua 2013;25(6):656-663.

Abstract: OBJECTIVE: To evaluate the impact of electronic standardized chemotherapy templates on incidence and types of prescribing errors., DESIGN: A quasi-experimental interrupted time series with segmented regression., SETTING: A 700-bed multidisciplinary tertiary care hospital with an ambulatory cancer center., PARTICIPANTS: A multidisciplinary team including oncology physicians, nurses, pharmacists and information technologists., INTERVENTION(S): Standardized, regimen-specific, chemotherapy prescribing forms were developed and implemented over a 32-month period., MAIN OUTCOME MEASURE(S): Trend of monthly prevented prescribing errors per 1000 chemotherapy doses during the pre-implementation phase (30 months), immediate change in the error rate from pre-implementation to implementation and trend of errors during the implementation phase. Errors were analyzed according to their types: errors in communication or transcription, errors in dosing calculation and errors in regimen frequency or treatment duration. Relative risk (RR) of errors in the post-implementation phase (28 months) compared with the pre-implementation phase was computed with 95% confidence interval (CI)., RESULTS: Baseline monthly error rate was stable with 16.7 prevented errors per 1000 chemotherapy doses. A 30% reduction in prescribing errors was observed with initiating the intervention. With implementation, a negative change in the slope of prescribing errors was observed (coefficient = -0.338; 95% CI: -0.612 to -0.064). The estimated RR of transcription errors was 0.74; 95% CI (0.59-0.92). The estimated RR of dosing calculation errors was 0.06; 95% CI (0.03-0.10). The estimated RR of chemotherapy frequency/duration errors was 0.51; 95% CI (0.42-0.62)., CONCLUSIONS: Implementing standardized chemotherapy-prescribing templates significantly reduced all types of prescribing errors and improved chemotherapy safety.

Haynes K, Linkin DR, Fishman NO, Bilker WB, Strom BL, Pifer EA, et al. **Effectiveness of an information technology intervention to improve prophylactic antibacterial use in the postoperative period**. Journal of the American Medical Informatics Association : JAMIA 2011;18(2):164-168.

Abstract: BACKGROUND: A 2005 report from the Centers for Medicare and Medicaid Services and the Centers for Disease Control Surgical Infection Prevention program indicated that only 41% of prophylactic antibacterials were correctly stopped within 24 h of the end of surgery. Electronic order sets have shown promise as a means of integrating guideline information with electronic order entry systems and facilitating safer, more effective care., OBJECTIVE: The aim was to study the effectiveness of a computer-based antibacterial order set on increasing the proportion of patients who have antibacterial wound prophylaxis discontinued in the appropriate time frame., DESIGN: The authors conducted a quasi-experimental interrupted time-series analysis over an 8-month study period with the implementation of a computer-based order system designed to prevent excessive duration of surgical prophylaxis antibacterials., MEASUREMENT: The primary outcome was the proportion of surgeries with antibacterials discontinued in the appropriate time frame. Additionally, we evaluated the percent of surgeries after implementation of the electronic intervention with chart documentation of infection among surgeries where the prescriber indicated the reason for antibacterial therapy was treatment., RESULTS: The computer-based order intervention significantly improved the proportion of surgeries with timely discontinuation of antibacterials from 38.8% to 55.7% ($p < 0.001$) in the intervention hospital, while the control hospital remained at 56-57% ($p = 0.006$ for the difference between treated and control hospitals). In surgeries after intervention implementation where a prescriber indicated the reason for antibacterial therapy was treatment, the prevalence of chart documented infection was only 14%., CONCLUSIONS: A computer-based electronic order set intervention increased timely discontinuation of postoperative antibacterials.

Wong BW, Mamdani MM, Yu CHY. **Impact of computerized insulin order sets on inpatient glycemic control & processes of care: An interrupted time-series study**. Canadian Journal of Diabetes 2013;37:S13-S14.

Abstract: The impact of computerized physician order entry (CPOE)-integrated order sets on inpatient diabetes care is unclear. Studies have been fraught with short follow-up times or samples limited in size and scope. In instances when large-scale randomized controlled trials are not feasible, interrupted time series (ITS) has been advocated as an alternative that can provide robust estimates of intervention effects while taking into account secular trends. We conducted an ITS to evaluate the longitudinal impact on glycemic control and insulin ordering 6 months before and after implementation of a CPOE-integrated insulin order set favouring the basal-bolus-supplement (BBS) approach and use of insulin sensitivity factors. This order set was made available to all the medical and surgical non-intensive care units at a tertiary centre with 550 beds. From June 2011 to June 2012, 46 795 capillary blood glucose (CBG) measurements were obtained. There was no impact of CPOE insulin order sets on proportion of CBGs in optimal range (4.0 to 7.0 mmol/L, $p=0.853$), hyperglycemia (>11.0 mmol/L, $p=0.815$) nor hypoglycemia (<4.0 mmol/L, $p=0.272$). There was no difference in overall uptake of BBS orders, which remained low (15.5% vs. 18.9%). Our findings demonstrated a lack of effectiveness of the CPOE insulin order sets, which may be due to knowledge gaps in the appropriate use of BBS approach, the need for a systematic order set implementation strategy, possible impedance of CPOE on user performance and the generation of new errors unique to computerized systems. Future research areas include conducting usability heuristic evaluations and developing platforms for continuous quality improvement.

Observassjonsstudier

Ballesca MA, LaGuardia JC, Lee PC, Hwang AM, Park DK, Gardner MN, et al. **An electronic order set for acute myocardial infarction is associated with improved patient outcomes through better adherence to clinical practice guidelines**. Journal of hospital medicine: an official publication of the Society of Hospital Medicine 2014;9(3):155-161.

Abstract: BACKGROUND: Adherence to evidence-based recommendations for acute myocardial infarction (AMI) remains unsatisfactory., OBJECTIVE: Quantifying association between using an electronic AMI order set (AMI-OS) and hospital processes and outcomes., DESIGN: Retrospective cohort study., SETTING: Twenty-one community hospitals., PATIENTS: A total of 5879 AMI patients were hospitalized between September 28, 2008 and December 31, 2010., MEASUREMENTS: We ascertained whether patients were treated using

the AMI-OS or individual orders (a la carte). Dependent process variables were use of evidence-based care; outcome variables were mortality and rehospitalization., RESULTS: Use of individual and combined therapies improved outcomes (eg, 50% lower odds of 30-day mortality for patients with >3 therapies). The 3531 patients treated using the AMI-OS were more likely to receive evidence-based therapies (eg, 50% received 5 different therapies vs 36% a la carte). These patients had lower 30-day mortality (5.7% vs 8.5%) than the 2348 treated using a la carte orders. Although AMI-OS patients' predicted mortality risk was lower (3.2%) than that of a la carte patients (4.8%), the association of improved processes and outcomes with the use of the AMI-OS persisted after risk adjustment. For example, after inverse probability weighting, the relative risk for inpatient mortality in the AMI-OS group was 0.67 (95% confidence interval: 0.52-0.86). Inclusion of use of recommended therapies in risk adjustment eliminated the benefit of the AMI-OS, highlighting its mediating effect on adherence to evidence-based treatment., CONCLUSIONS: Use of an electronic order set is associated with increased adherence to evidence-based care and better AMI outcomes.

Carroll NV, Smith JC, Berringer RA, Oestreich GL. **Evaluation of an automated system for prior authorization: a COX-2 inhibitor example**. The American journal of managed care 2006;12(9):501-508.

Abstract: OBJECTIVE: To evaluate the effectiveness of an automated prior authorization (PA) system (SmartPA) in reducing use of and expenditures for cyclooxygenase-2 (COX-2) inhibitors., STUDY DESIGN: Before and after with control group., METHODS: After implementation of SmartPA in Missouri, changes in use of and expenditures for COX-2 inhibitors, COX-2 substitutes (traditional nonsteroidal anti-inflammatory drugs [NSAIDs] and other products for pain), and gastrointestinal (GI) protective agents were compared between the Medicaid program of Missouri and that of a state with no PA program for COX-2 inhibitors. Subjects were continuously enrolled for the 24-month study period and had a claim for a COX-2 inhibitor in the 12-month baseline period. Analyses included comparison of means and linear regression. Regressions controlled for age, sex, risk for GI complications, severity of illness, and the interaction between state and risk., RESULTS: Changes in expenditures for COX-2 inhibitors, NSAIDs, other pain drugs, and GI-protective drugs were $256 higher, $56 lower, $21 higher, and $198 higher, respectively, in the control state among low-risk patients. Changes in expenditures were $102 higher, $12 lower, $21 lower, and $185 higher, respectively, in the control state among high-risk patients. Results were similar for drug utilization., CONCLUSION: Implementation of SmartPA resulted in reduced use of and expenditures for COX-2 inhibitors and reduced net expenditures for all pain and GI-protective medications. These effects were greatest for patients at low risk for GI complications.

Cox ZL, Nelsen CL, Waitman LR, McCoy JA, Peterson JF. **Effects of clinical decision support on initial dosing and monitoring of tobramycin and amikacin**. American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists 2011;68(7):624-632.

Abstract: PURPOSE: The impact of clinical decision support (CDS) on initial doses and intervals and pharmacokinetic outcomes of amikacin and tobramycin therapy was evaluated., METHODS: A complex CDS advisor to provide guidance on initial dosing and monitoring of aminoglycoside orders, using both traditional-dosing and extended-interval-dosing strategies, was integrated into a computerized prescriber-order-entry (CPOE) system and compared with a control group whose aminoglycoside orders were closely monitored by pharmacists. The primary outcome measured was an initial dose within 10% of a dose calculated to be adherent to published dose guidelines. Secondary outcomes included a guideline-adherent interval, trough and peak concentrations in goal range, and rate of nephrotoxicity., RESULTS: Of 216 patients studied, 97 were prescribed amikacin and 119 were prescribed tobramycin. The number of orders with initial doses consistent with reference standards increased from 40% in the preadvisor group to 80% in the postadvisor group ($p < 0.001$). Selection of the correct initial interval based on renal function increased from 63% to 87% ($p < 0.001$). The changes in the initial dosing and interval resulted in an increase of trough concentrations at goal (59% in the preadvisor group versus 89% in the postadvisor group, $p = 0.0004$). There was no significant difference in peak concentrations in the goal range or rate of nephrotoxicity., CONCLUSION: An advisor for aminoglycoside dosing and monitoring integrated into a CPOE system significantly improved selection of initial doses and intervals and resulted in an improvement in the rate of trough serum drug concentrations at goal compared with standard provider dosing.

Fleming NS, Ogola G, Ballard DJ. **Implementing a standardized order set for community-acquired pneumonia: impact on mortality and cost**. Joint Commission journal on quality and patient safety / Joint Commission Resources 2009;35(8):414-421.

Abstract: BACKGROUND: Order sets have shown some success in improving compliance with clinical guidelines, as well as patient and financial outcomes. Baylor Health Care System (BHCS) deployed a standardized adult pneumonia order set throughout its eight acute care hospitals in 2006., METHODS: All non-comfort care adult patients admitted with community-acquired pneumonia who met The Joint Commission definition of pneumonia and were discharged from an acute care BHCS hospital for a 30-month period (March 1, 2006-August 31, 2008) were included. Mortality, core measures compliance, and direct cost were compared for patients who did and did not receive the order set., RESULTS: Some 4,454 patients met study inclusion criteria. Significant variation in use between hospitals, however, persisted. Unadjusted analysis showed significant reductions in inhospital mortality, 30-day mortality, and direct cost and a significant increase in core measures compliance. Following risk adjustment, the difference in core measures compliance was retained (relative risk [95% confidence interval (C.I.)] 1.08 [1.03, 1.12]). Inhospital mortality and 30-day mortality reductions both approached significance (hazard ratios [95% C.I.] of 0.73 [0.51,1.02] and 0.79 [0.62, 1.00], respectively). Mean (standard error) benefits of order set use in inhospital mortality and costs were estimated at 1.67 (0.62)% and $383 (207). The incremental cost-effectiveness ratio point estimate was -$22,882 per life saved, with an upper 95% confidence limit of$1,278 per life saved., DISCUSSION: Widespread adoption of the order set was achieved, with use consistently at or above 75% across all BHCS acute care hospitals since February 2007. The reductions in mortality observed with order set use, in combination with the favorable estimate of cost-effectiveness, make standardized evidence-based order sets an attractive improvement methodology for improving quality of pneumonia care.

Milani RV, Lavie CJ, Dornelles AC. **The impact of achieving perfect care in acute coronary syndrome: the role of computer assisted decision support**. Am Heart J 2012;164(1):29-34.

Abstract: BACKGROUND: Attainment of every performance measure or perfect care (PC) is used as a tool for measuring hospital quality of care. We sought to describe the effect of achieving PC on subsequent outcomes in patients admitted with acute coronary syndrome (ACS) and to determine whether computerized physician order entry enabled with decision support (CPOE-DS) would enhance the likelihood of achieving PC and improvements in clinical outcomes., METHODS: Clinical inpatient data, performance measures and subsequent mortality was collected in 1,321 consecutive ACS patients admitted between January 1, 2009, to October 15, 2011, using either a standardized order set that followed consensus guidelines or orders generated via CPOE-DS., RESULTS: CPOE-DS generated orders were utilized in 642 (49%) patients while the remaining 679 (51%) of patients were admitted using standardized order sets. At baseline, CPOE-DS patients were younger (-3%, P = .006), had lower resting heart rates (-3%, P = .012), higher TIMI risk scores (+19%, P < .001), were less likely to have hypertension (85% vs. 90%, P = .014), and more likely to have ST-segment elevation myocardial infarction (17% vs 10%; P = .001) than patients admitted with standard orders. Patients admitted using CPOE-DS were 5.7 times more likely to achieve PC than those who were admitted with standard orders (P < .001). Independent predictors of survival included PC (HR, 0.45; P < .001), age >67 years (HR, 2.34; P < .001), and abnormal presenting heart rate (HR, 1.71; P = .046)., CONCLUSIONS: Achievement of PC is a valid measure of quality of care in the hospitalized ACS patient and is associated with improved survival. CPOE-DS is feasible in the care process for ACS and can increase attainment of PC.

Milani RV, Oleck SA, Lavie CJ. **Medication errors in patients with severe chronic kidney disease and acute coronary syndrome: the impact of computer-assisted decision support**. Mayo Clin Proc 2011;86(12):1161-1164.

Abstract: OBJECTIVE: To evaluate the impact of computerized physician order entry (CPOE) with decision support on the frequency of antithrombotic medication errors in patients with chronic kidney disease (CKD) admitted with acute coronary syndrome (ACS) and to measure what effect it would have on in-hospital bleeding., PATIENTS AND METHODS: We evaluated 80 patients with CKD who were admitted with ACS between January 1, 2009, and December 31, 2010, using either a standardized order set or CPOE with decision support to assess the frequency of medication errors and in-hospital bleeding., RESULTS: Of the 80

patients, 47 were admitted with standard orders vs 33 with CPOE. In-hospital bleeding occurred in 13 patients: 10 in the standard orders group vs 3 in the CPOE group (P=.12). In-hospital bleeding occurred in 5 (63%) of 8 patients receiving a contraindicated antithrombotic medication compared with 8 (11%) of 72 patients receiving appropriate medications (P=.002); the corresponding length of stay was 12.0 days compared with 6.8 days (P=.10). Contraindicated medications were given to no patients in the CPOE group vs 8 patients (17%) in the standard orders group (P=.01)., CONCLUSION: Medication errors occur frequently in patients with CKD admitted with ACS and result in a high risk of in-hospital bleeding. Use of CPOE with decision support is feasible in the ACS setting and may lead to improved patient safety.

Peterson JF, Kuperman GJ, Shek C, Patel M, Avorn J, Bates DW. **Guided prescription of psychotropic medications for geriatric inpatients**. Arch Intern Med 2005;165(7):802-807.

Abstract: Background: Inappropriate use or excessive dosing of psychotropic medications in the elderly is common and can lead to a variety of adverse drug events including falls, oversedation, and cognitive impairment. Methods: We developed a database of psychotropic medication dosing and selection guidelines for elderly inpatients. We displayed these recommendations to physicians through a computerized order entry system at a tertiary care academic hospital. The system was activated for 2 of 4 six-week study periods in an off-on-off-on pattern. Main outcome measures were agreement with the recommended daily dose for the initial drug order, incidence of dosing at least 10-fold greater than the recommended daily dose, prescription of nonrecommended drugs, inpatient falls, altered mental status as measured by a brief nursing assessment, and hospital length of stay. Results: A total of 7456 initial orders for psychotropic medications were prescribed for 3718 hospitalized elderly patients with a mean+/-SD age of 74.7+/-6.7 years. The intervention increased the prescription of the recommended daily dose (29% vs 19%; P<.001), reduced the incidence of 10-fold dosing (2.8% vs 5.0%; P<.001), and reduced the prescription of nonrecommended drugs (10.8% vs 7.6% of total orders; P<.001). Patients in the intervention cohort had a lower in-hospital fall rate (0.28 vs 0.64 falls per 100 patient-days; P=.001). No effect on hospital length of stay or days of altered mental status was found. Conclusion: A geriatric decision support system for psychotropic medications increased the prescription of recommended doses, reduced the prescription of nonrecommended drugs, and was associated with fewer inpatient falls.

Peterson JF, Rosenbaum BP, Waitman LR, Habermann R, Powers J, Harrell D, et al. **Physicians' response to guided geriatric dosing: initial results from a randomized trial**. Stud Health Technol Inform 2007;129(Pt 2):1037-1040.

Abstract: Guided dosing within a computerized provider order entry (CPOE) system is an effective method of individualizing therapy for patients. Physicians' responses to guided dosing decision support have not been extensively studied. As part of a randomized trial evaluating efficacy of dosing advice on reducing falls in the elderly, CPOE prompts to physicians for 88 drugs included tailored messages and guided dose lists with recommended initial doses and frequencies. The study captured all prescribing activity electronically. The primary outcome was the ratio between prescribed dose and recommended dose. Over 9 months, 778 providers entered 9111 study-related medication orders on 2981 patients. Physicians using guided orders chose recommended doses more often than controls(28.6% vs. 24.1%, p<0.001). Selected doses were significantly lower in the intervention group (median ratio of actual to recommended 2.5, interquartile range [1.0,4.0]) than the control group (median 3.0 interquartile range [1.5,5.0], p<0.001). While physicians selected the recommended dose less than a third of the time, guided geriatric dosing modestly improved compliance with guidelines.

Wrona S, Chisolm DJ, Powers M, Miler V. **Improving processes of care in patient-controlled analgesia: the impact of computerized order sets and acute pain service patient management**. Paediatr Anaesth 2007;17(11):1083-1089.

Abstract: BACKGROUND: In an effort to combat opioid induced side effects within the first 24 h of patient-controlled analgesia (PCA) induction, it has been recommended that care be provided by an Acute Pain Treatment Service (APS) and that computerized PCA order sets with patient monitoring requirements be implemented. To date, there are few published studies on the role of computerized order sets or APS in improving the quality and

safety of pediatric PCA use. This retrospective analysis sought to determine if the implementation of computerized order sets would increase appropriate monitoring and problem recognition., METHODS: Analysis included 536 patients prescribed PCA in one of three ways: an anesthesia order set with APS support (n = 285), a general PCA order set (n = 95), or no order set (n = 156). We analyzed the use of order sets by unit; the incidence of appropriate monitoring (> or =12 recordings within 24 h) of respiratory rate, oxygen saturation, and sedation level and the recognition of low respiration rate and low oxygen saturation between the types of PCA order., RESULTS: We found a significant difference in type of PCA order used by unit. Appropriate documentation of respiratory rate and oxygen saturation occurred significantly more often if the order set with APS was used. Low respiration rate was also recognized significantly more frequently (P < or = 05) in the APS order set group., CONCLUSIONS: These findings show that use of a computerized PCA order set with monitoring requirements and an APS can increase monitoring and documentation of important vital signs and increase identification of potential negative events.

Elektronisk foreskrivning

RCT

Avansino J, Leu MG. **Effects of CPOE on provider cognitive workload: a randomized crossover trial**. Pediatrics 2012;130(3):e547-552.

Abstract: OBJECTIVE: To evaluate whether systematically developed clinical decision supports provide usability benefit or decreased cognitive workload with their use., METHODS: Seven surgeons at a pediatric hospital at different levels of training (3 residents, 3 fellows, and 1 attending) were randomized to use either a historical control (ad hoc developed order set) or a systematically developed order set for postoperative management of appendicitis in children. After a washout period, they were crossed over to the other order set. Participants were videorecorded and completed postsurveys, including the System Usability Scale and the National Aeronautic and Space Administration-Task Load Index., RESULTS: Participants unanimously preferred using systematically developed order sets. These order sets resulted in higher usability scores (75 +/- 10 vs 60 +/- 19; P < .05) and lower cognitive workload scores (37.7 +/- 15 vs 52.2 +/- 12; P < .05), with comparable amounts of time spent, mouse clicks, and free text entry. Orders generated were more likely to conform to established clinical guidelines., CONCLUSIONS: Systematically designed order sets provide a reduction in cognitive workload and order variation in the context of improved system usability and improved guideline adherence. The systematically designed order set did not improve time spent, reduce mouse clicks, or reduce free text entry.

Dainty KN, Adhikari NKJ, Kiss A, Quan S, Zwarenstein M. **Electronic prescribing in an ambulatory care setting: a cluster randomized trial**. J Eval Clin Pract 2012;18(4):761-767.

Abstract: RATIONALE, AIMS AND OBJECTIVES: Medication-prescribing errors with adverse drug events impose substantial harms on patients and health systems. Medication errors resulting in preventable adverse drug events most commonly occur at the ordering stage. Electronic prescribing may prevent such errors but its impact has not been rigorously evaluated., METHODS: We conducted a pragmatic cluster randomized controlled trial in academic hospital ambulatory clinics to evaluate the effects of a commercially available electronic prescribing software system on total prescription error ratio. Secondary outcomes included the number of callbacks for clarification from community pharmacies to physicians' clinics., RESULTS: Twenty-six physicians used the electronic prescribing system, writing 1980 prescriptions during 44 intervention weeks when the electronic prescribing system was available (7.6% of these were electronic, the remainder handwritten) and 973 prescriptions during 22 control weeks while the system was switched off (1.4% electronic, prescribed in the previous intervention week, but issued with delay). The total prescription error rate was 118/1980 (6.0%) in intervention weeks and 57/973 (5.9%) in control weeks (P = 0.91). During the intervention period more callbacks requesting clarification were made to clinic administrators (n = 83, 1.89 per week) than during control weeks (n = 32, 1.45 per week; P < 0.001)., CONCLUSION: Implementation of the electronic prescribing system had no impact on total prescription error, and increased the callback rate. In spite of intensive user support, few prescriptions in intervention weeks were made using the electronic system. Given the

costs, training requirements, workflow redesigns and regulatory hurdles, additional evaluations of outpatient prescribing on clinically important outcomes are needed.Copyright © 2011 Blackwell Publishing Ltd.

Graumlich JF, Novotny NL, Nace GS, Aldag JC. **Patient and physician perceptions after software-assisted hospital discharge: cluster randomized trial**. J Hosp Med 2009;4(6):356-363.

Abstract: BACKGROUND: Hospital discharge software potentially improves communication and clinical outcomes., OBJECTIVE: To measure patient and physician perceptions after discharge with computerized physician order entry (CPOE) software., DESIGN: Cluster randomized controlled trial., SETTING: Tertiary care, teaching hospital in central Illinois., PATIENTS: A total of 631 inpatients discharged to home with high risk for readmission., INTERVENTION: A total of 70 internal medicine hospital physicians randomly assigned (allocation concealed) to discharge software vs. usual care, handwritten discharge., MEASUREMENTS: Discharge perceptions from patients, outpatient primary care physicians, and hospital physicians., RESULTS: One week after discharge, 92.4% (583/631) of patients answered interviews. For 78.6% (496/631) of patients, their outpatient physicians returned questionnaires 19 days (median) postdischarge. Generalized estimating equations gave intervention variable coefficients with 95% confidence intervals (CIs). When comparing patients assigned to discharge software vs. usual care, patient mean (standard deviation [SD]) scores for discharge preparedness were higher (17.7 [4.1] vs. 17.2 [4.0]; coefficient = 0.147; 95% CI = 0.005-0.289; P = 0.042), patient scores for satisfaction with medication information were unchanged (12.3 [4.8] vs. 12.1 [4.6]; coefficient = -0.212; 95% CI = -0.937-0.513; P = 0.567), and their outpatient physicians scored higher quality discharge (17.2 [3.8] vs. 16.5 [3.9]; coefficient = 0.133; 95% CI = 0.015-0.251; P = 0.027). Hospital physicians found mean effort to use discharge software was more difficult than the usual care (6.5 [1.9] vs. 7.9 [2.1]; P = 0.011)., CONCLUSIONS: Discharge software with CPOE caused small improvements in discharge perceptions by patients and their outpatient physicians. These small improvements might balance the difficulty perceived by hospital physicians who used discharge software.

Graumlich JF, Novotny NL, Stephen Nace G, Kaushal H, Ibrahim-Ali W, Theivanayagam S, et al. **Patient readmissions, emergency visits, and adverse events after software-assisted discharge from hospital: cluster randomized trial**. J Hosp Med 2009;4(7):E11-19.

Abstract: BACKGROUND: One of the causes of postdischarge adverse events is poor discharge communication between hospital-based physicians, patients, and outpatient physicians. The value of hospital discharge software to improve communication and clinically relevant outcomes is unknown., OBJECTIVE: To measure effects of a discharge software application of computerized physician order entry (CPOE)., DESIGN: Cluster randomized controlled trial., SETTING: Tertiary care, teaching hospital in central Illinois., PATIENTS: A total of 631 inpatients discharged to home with high risk for readmission., INTERVENTION: Seventy internal medicine hospital physicians were randomly assigned (allocation concealed) to discharge software versus usual care, handwritten discharge., MEASUREMENTS: Blinded assessment of patient readmission, emergency department visit, and postdischarge adverse event., RESULTS: A total of 590 (94%) patients provided 6-month follow-up data. Generalized estimating equations gave intervention variable coefficients with 95% confidence interval (CI). When comparing patients assigned to discharge software versus usual care, there was no difference in hospital readmission within 6 months (37.0% versus 37.8%; coefficient -0.005 [95% CI, -0.074 to 0.065]; P = 0.894), emergency department visit within 6 months (35.4% versus 40.6%; coefficient -0.052 [95% CI, -0.115 to 0.011]; P = 0.108), or adverse event within 1 month (7.3% versus 7.3%; coefficient 0.003 [95% CI; -0.037 to 0.043]; P = 0.884)., CONCLUSIONS: Discharge software with CPOE did not affect readmissions, emergency department visits, or adverse events after discharge. Future studies should assess other endpoints such as patient perceptions or physician perceptions to see if discharge software has value.Copyright 2009 Society of Hospital Medicine.

Controlled trial

Chan J, Shojania KG, Easty AC, Etchells EE. **Does user-centred design affect the efficiency, usability and safety of CPOE order sets?** Journal of the American Medical Informatics Association : JAMIA 2011;18(3):276-281.

Abstract: BACKGROUND: Application of user-centred design principles to Computerized provider order entry (CPOE) systems may improve task efficiency, usability or safety,

but there is limited evaluative research of its impact on CPOE systems., OBJECTIVE: We evaluated the task efficiency, usability, and safety of three order set formats: our hospital's planned CPOE order sets (CPOE Test), computer order sets based on user-centred design principles (User Centred Design), and existing pre-printed paper order sets (Paper)., PARTICIPANTS: 27 staff physicians, residents and medical students., SETTING: Sunnybrook Health Sciences Centre, an academic hospital in Toronto, Canada. Methods Participants completed four simulated order set tasks with three order set formats (two CPOE Test tasks, one User Centred Design, and one Paper). Order of presentation of order set formats and tasks was randomized. Users received individual training for the CPOE Test format only., MAIN MEASURES: Completion time (efficiency), requests for assistance (usability), and errors in the submitted orders (safety)., RESULTS: 27 study participants completed 108 order sets. Mean task times were: User Centred Design format 273 s, Paper format 293 s ($p=0.73$ compared to UCD format), and CPOE Test format 637 s ($p<0.0001$ compared to UCD format). Users requested assistance in 31% of the CPOE Test format tasks, whereas no assistance was needed for the other formats ($p<0.01$). There were no significant differences in number of errors between formats., CONCLUSIONS: The User Centred Design format was more efficient and usable than the CPOE Test format even though training was provided for the latter. We conclude that application of user-centred design principles can enhance task efficiency and usability, increasing the likelihood of successful implementation.

ITS

Bates DW, Teich JM, Lee J, Seger D, Kuperman GJ, Ma'Luf N, et al. **The impact of computerized physician order entry on medication error prevention**. Journal of the American Medical Informatics Association : JAMIA 1999;6(4):313-321.

Abstract: BACKGROUND: Medication errors are common, and while most such errors have little potential for harm they cause substantial extra work in hospitals. A small proportion do have the potential to cause injury, and some cause preventable adverse drug events., OBJECTIVE: To evaluate the impact of computerized physician order entry (POE) with decision support in reducing the number of medication errors., DESIGN: Prospective time series analysis, with four periods., SETTING AND PARTICIPANTS: All patients admitted to three medical units were studied for seven to ten-week periods in four different years. The baseline period was before implementation of POE, and the remaining three were after. Sophistication of POE increased with each successive period., INTERVENTION: Physician order entry with decision support features such as drug allergy and drug-drug interaction warnings., MAIN OUTCOME MEASURE: Medication errors, excluding missed dose errors., RESULTS: During the study, the non-missed-dose medication error rate fell 81 percent, from 142 per 1,000 patient-days in the baseline period to 26.6 per 1,000 patient-days in the final period ($P < 0.0001$). Non-intercepted serious medication errors (those with the potential to cause injury) fell 86 percent from baseline to period 3, the final period ($P = 0.0003$). Large differences were seen for all main types of medication errors: dose errors, frequency errors, route errors, substitution errors, and allergies. For example, in the baseline period there were ten allergy errors, but only two in the following three periods combined ($P < 0.0001$)., CONCLUSIONS: Computerized POE substantially decreased the rate of non-missed-dose medication errors. A major reduction in errors was achieved with the initial version of the system, and further reductions were found with addition of decision support features.

Coleman JJ, Hodson J, Brooks HL, Rosser D. **Missed medication doses in hospitalised patients: a descriptive account of quality improvement measures and time series analysis**. International journal for quality in health care : journal of the International Society for Quality in Health Care / ISQua 2013;25(5):564-572.

Abstract: OBJECTIVE: To investigate the changes in overdue doses rates over a 4-year period in an National Health Service (NHS) teaching hospital, following the implementation of interventions associated with an electronic prescribing system used within the hospital., DESIGN: Retrospective time-series analysis of weekly dose administration data., SETTING: University teaching hospital using a locally developed electronic prescribing and administration system (Prescribing, Information and Communication System or PICS) with an audit database containing details on every drug prescription and dose administration., PARTICIPANTS: Prescription data extracted from the PICS database., INTERVENTION(S): Four interventions were implemented in the Trust: (i) the ability for doctors to pause medication doses; (ii) clinical dashboards; (iii) visual indicators for overdue doses and (iv) overdue doses Root Cause, ANALYSIS: (RCA) meetings and a National Patient Safety Agency (NPSA) Rapid

Response Alert. Main outcome measure(s) The percentage of missed medication doses., RESULTS: Rates of both missed antibiotic and non-antibiotic doses decreased significantly upon the introduction of clinical dashboards (reductions of 0.60 and 0.41 percentage points, respectively), as well as following the instigation of executive-led overdue doses RCA meetings (reductions of 0.83 and 0.97 percentage points, respectively) and the publication of an associated NPSA Rapid Response Alert. Implementing a visual indicator for overdue doses was not associated with significant decreases in the rates of missed antibiotic or non-antibiotic doses., CONCLUSIONS: Electronic prescribing systems can facilitate data collection relating to missed medication doses., INTERVENTIONS: providing hospital staff with information about overdue doses at a ward level can help promote reductions in overdue doses rates.

Magid S, Forrer C, Shaha S. **Duplicate orders: an unintended consequence of computerized provider/physician order entry (CPOE) implementation: analysis and mitigation strategies**. Appl Clin Inform 2012;3(4):377-391.

Abstract: OBJECTIVE: Computerized provider/physician order entry (CPOE) with clinical decision support (CDS) is designed to improve patient safety. However, a number of unintended consequences which include duplicate ordering have been reported. The objective of this time-series study was to characterize duplicate orders and devise strategies to minimize them., METHODS: Time series design with systematic weekly sampling for 84 weeks. Each week we queried the CPOE database, downloaded all active orders onto a spreadsheet, and highlighted duplicate orders. We noted the following details for each duplicate order: time, order details (e.g. drug, dose, route and frequency), ordering prescriber, including position and role, and whether the orders originated from a single order or from an order set (and the name of the order set). This analysis led to a number of interventions, including changes in: order sets, workflow, prescriber training, pharmacy procedures, and duplicate alerts., RESULTS: Duplicates were more likely to originate from different prescribers than from same prescribers; and from order sets than from single orders. After interventions, there was an 84.8% decrease in the duplication rate from weeks 1 to 84 and a 94.6% decrease from the highest (1) to the lowest week (75). Currently, we have negligible duplicate orders., CONCLUSIONS: Duplicate orders can be a significant unintended consequence of CPOE. By analyzing these orders, we were able to devise and implement generalizable strategies that significantly reduced them. The incidence of duplicate orders before CPOE implementation is unknown, and our data originate from a weekly snapshot of active orders, which serves as a sample of total active orders. Thus, it should be noted that this methodology likely under-reports duplicate orders.

Maat B, Rademaker CMA, Oostveen MI, Krediet TG, Egberts TCG, Bollen CW. **The effect of a computerized prescribing and calculating system on hypo- and hyperglycemias and on prescribing time efficiency in neonatal intensive care patients**. JPEN Journal of parenteral and enteral nutrition 2013;37(1):85-91.

Abstract: BACKGROUND: Prescribing glucose requires complex calculations because glucose is present in parenteral and enteral nutrition and drug vehicles, making it error prone and contributing to the burden of prescribing errors., OBJECTIVE: Evaluation of the impact of a computerized physician order entry (CPOE) system with clinical decision support (CDS) for glucose control in neonatal intensive care patients (NICU) focusing on hypo- and hyperglycemic episodes and prescribing time efficiency., METHODS: An interrupted time-series design to examine the effect of CPOE on hypo- and hyperglycemias and a crossover simulation study to examine the influence of CPOE on prescribing time efficiency. NICU patients at risk for glucose imbalance hospitalized at the University Medical Center Utrecht during 2001-2007 were selected. The risks of hypo- and hyperglycemias were expressed as incidences per 100 patient days in consecutive 3-month intervals during 3 years before and after CPOE implementation. To assess prescribing time efficiency, time needed to calculate glucose intake with and without CPOE was measured., RESULTS: No significant difference was found between pre- and post-CPOE mean incidences of hypo- and hyperglycemias per 100 hospital days of neonates at risk in every 3-month period (hypoglycemias, 4.0 [95% confidence interval, 3.2-4.8] pre-CPOE and 3.1 [2.7-3.5] post-CPOE, P = .88; hyperglycemias, 6.0 [4.3-7.7] pre-CPOE and 5.0 [3.7-6.3] post-CPOE, P = .75). CPOE led to a significant time reduction of 16% (1.3 [0.3-2.3] minutes) for simple and 60% (8.6 [5.1-12.1] minutes) for complex calculations., CONCLUSIONS: CPOE including a special CDS tool preserved accuracy for calculation and control of glucose intake and increased prescribing time efficiency.

Pawar DS. **The impact of computerized physician order entry system (CPOE) on occurrence of medication errors in a psychiatric hospital**. Drug Inf J 2009;43 (4):523.

Abstract: Objective: To evaluate the impact of computerized physician order entry system (CPOE) on occurrence of medication errors. Method: Inpatient data of an academic psychiatric hospital during January 2003-December 2008 was collected. Medication error rate per 100 prescriptions per month was primary outcome. Interrupted time-series regression analysis was used to study the impact of CPOE system on occurrence of medication errors. Results: The average prevalence of medication errors during the study period was 4.4%. Most of the medication errors were inappropriate dosing errors (32.69% in 2008 and 29.56% in 2007). After the implementation of CPOE (February 2004) the medication error rate dropped by 9.72% (P value = .0033). Conclusion: CPOE system showed a substantial potential for preventing medication errors and improving the quality of care in psychiatric services.

van Doormaal JE, van den Bemt PMLA, Zaal RJ, Egberts ACG, Lenderink BW, Kosterink JGW, et al. **The influence that electronic prescribing has on medication errors and preventable adverse drug events: an interrupted time-series study**. Journal of the American Medical Informatics Association : JAMIA 2009;16(6):816-825.

Abstract: OBJECTIVE: This study evaluated the effect of a Computerized Physician Order Entry system with basic Clinical Decision Support (CPOE/CDSS) on the incidence of medication errors (MEs) and preventable adverse drug events (pADEs)., DESIGN: Interrupted time-series design., MEASUREMENTS: The primary outcome measurements comprised the percentage of medication orders with one or more MEs and the percentage of patients with one or more pADEs., RESULTS: Pre-implementation, the mean percentage of medication orders containing at least one ME was 55%, whereas this became 17% post-implementation. The introduction of CPOE/CDSS has led to a significant immediate absolute reduction of 40.3% (95% CI: -45.13%; -35.48%) in medication orders with one or more errors. Pre-implementation, the mean percentage of admitted patients experiencing at least one pADE was 15.5%, as opposed to 7.3% post-implementation. However, this decrease could not be attributed to the introduction of CPOE/CDSS: taking into consideration the interrupted time-series design, the immediate change was not significant (-0.42%, 95% CI: -15.52%; 14.68%) because of the observed underlying negative trend during the pre-CPOE period of -4.04% [95% CI: -7.70%; -0.38%] per month., CONCLUSIONS: This study has shown that CPOE/CDSS reduces the incidence of medication errors. However, a direct effect on actual patient harm (pADEs) was not demonstrated.

Vermeulen KM, van Doormaal JE, Zaal RJ, Mol PGM, Lenderink AW, Haaijer-Ruskamp FM, et al. **Cost-effectiveness of an electronic medication ordering system (CPOE/CDSS) in hospitalized patients**. Int J Med Inform 2014;83(8):572-580.

Abstract: INTRODUCTION: Prescribing medication is an important aspect of almost all in-hospital treatment regimes. Besides their obviously beneficial effects, medicines can also cause adverse drug events (ADE), which increase morbidity, mortality and health care costs. Partially, these ADEs arise from medication errors, e.g. at the prescribing stage. ADEs caused by medication errors are preventable ADEs. Until now, medication ordering was primarily a paper-based process and consequently, it was error prone. Computerized Physician Order Entry, combined with basic Clinical Decision Support System (CPOE/CDSS) is considered to enhance patient safety. Limited information is available on the balance between the health gains and the costs that need to be invested in order to achieve these positive effects. Aim of this study was to study the balance between the effects and costs of CPOE/CDSS compared to the traditional paper-based medication ordering., METHODS: The economic evaluation was performed alongside a clinical study (interrupted time series design) on the effectiveness of CPOE/CDSS, including a cost minimization and a cost-effectiveness analysis. Data collection took place between 2005 and 2008. Analyses were performed from a hospital perspective. The study was performed in a general teaching hospital and a University Medical Centre on general internal medicine, gastroenterology and geriatric wards. Computerized Physician Order Entry, combined with basic Clinical Decision Support System (CPOE/CDSS) was compared to a traditional paper based system. All costs of both medication ordering systems are based on resources used and time invested. Prices were expressed in Euros (price level 2009). Effectiveness outcomes were medication errors and preventable adverse drug events., RESULTS: During the paper-based prescribing period 592 patients were included, and during the CPOE/CDSS period 603. Total costs of the paper-based system and

CPOE/CDSS amounted to 12.37 and 14.91 per patient/day respectively. The Incremental Cost-Effectiveness Ratio (ICER) for medication errors was 3.54 and for preventable adverse drug events 322.70, indicating the extra amount () that has to be invested in order to prevent one medication error or one pADE., CONCLUSIONS: CPOE with basic CDSS contributes to a decreased risk of preventable harm. Overall, the extra costs of CPOE/CDSS needed to prevent one ME or one pADE seem to be acceptable.

Walsh KE, Landrigan CP, Adams WG, Vinci RJ, Chessare JB, Cooper MR, et al. **Effect of computer order entry on prevention of serious medication errors in hospitalized children**. Pediatrics 2008;121(3):e421-427.

Abstract: OBJECTIVE: Although initial research suggests that computerized physician order entry reduces pediatric medication errors, no comprehensive error surveillance studies have evaluated the effect of computerized physician order entry on children. Our objective was to evaluate comprehensively the effect of computerized physician order entry on the rate of inpatient pediatric medication errors., METHODS: Using interrupted time-series regression analysis, we reviewed all charts, orders, and incident reports for 40 admissions per month to the NICU, PICU, and inpatient pediatric wards for 7 months before and 9 months after implementation of commercial computerized physician order entry in a general hospital. Nurse data extractors, who were unaware of study objectives, used an established error surveillance method to detect possible errors. Two physicians who were unaware of when the possible error occurred rated each possible error., RESULTS: In 627 pediatric admissions, with 12,672 medication orders written over 3234 patient-days, 156 medication errors were detected, including 70 nonintercepted serious medication errors (22/1000 patient-days). Twenty-three errors resulted in patient injury (7/1000 patient-days). In time-series analysis, there was a 7% decrease in level of the rates of nonintercepted serious medication errors. There was no change in the rate of injuries as a result of error after computerized physician order entry implementation., CONCLUSIONS: The rate of nonintercepted serious medication errors in this pediatric population was reduced by 7% after the introduction of a commercial computerized physician order entry system, much less than previously reported for adults, and there was no change in the rate of injuries as a result of error. Several human-machine interface problems, particularly surrounding selection and dosing of pediatric medications, were identified. Additional refinements could lead to greater effects on error rates.

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Abramson EL, Barron Y, Quaresimo J, Kaushal R. **Electronic prescribing within an electronic health record reduces ambulatory prescribing errors**. Joint Commission journal on quality and patient safety / Joint Commission Resources 2011;37(10):470-478.

Abstract: BACKGROUND: Health policy forces are promoting the adoption of interoperable electronic health records (EHRs) with electronic prescribing (e-prescribing). Despite the promise of EHRs with e-prescribing to improve medication safety in ambulatory care settings--where most prescribing occurs and where errors are common--few studies have demonstrated its effectiveness. A study was conducted to assess the effect of an e-prescribing system with clinical decision support, including checks for drug allergies and drug-drug interactions, that was integrated within an EHR on rates of ambulatory prescribing errors., METHODS: In a prospective study using a nonrandomized, pre-post design with concurrent controls, 6 providers who used a commercial e-prescribing system were compared with 15 providers who remained paper-based from September 2005 through July 2008. Prescribing errors were identified by a standardized prescription and chart review., RESULTS: Some 2,432 paper prescriptions at baseline and 2,079 prescriptions at one year were analyzed. Error rates for e-prescribing adopters decreased 1.5-fold--from 26.0 errors per 100 prescriptions at baseline (95% confidence interval [CI], 17.4-38.9) to 16.0 errors per 100 prescriptions at one year (95% CI, 12.7-20.2; p = .09). Error rates remained unchanged for nonadopters (37.3 per 100 prescriptions at baseline, 95% CI, 27.6-50.2, versus 38.4 per 100 prescriptions at one year, 95% CI 27.4-53.9; p = .54). Error rates for e-prescribing adopters were significantly lower than for nonadopters at one year (p < .001). Illegibility errors were high at baseline and eliminated by e-prescribing., CONCLUSIONS: The preliminary findings from this small group of providers suggest that e-prescribing systems may decrease ambulatory prescribing errors, which are occurring at high rates among community-based providers.

Beeler PE, Kucher N, Blaser J. **Sustained impact of electronic alerts on rate of prophylaxis against venous thromboembolism**. Thromb Haemost 2011;106(4):734-738.

Abstract: Advanced electronic alerts (eAlerts) and computerised physician order entry (CPOE) increase adequate thromboprophylaxis orders among hospitalised medical patients. It remains unclear whether eAlerts maintain their efficacy over time, after withdrawal of continuing medical education (CME) on eAlerts and on thromboprophylaxis indications from the study staff. We analysed 5,317 hospital cases from the University Hospital Zurich during 2006-2009: 1,854 cases from a medical ward with eAlerts (interventiongroup) and 3,463 cases from a surgical ward without eAlerts (controlgroup). In the intervention group, an eAlert with hospital-specific venous thromboembolism (VTE) prevention guidelines was issued in the electronic patient chart 6 hours after admission if no pharmacological or mechanical thromboprophylaxis had been ordered. Data were analysed for three phases: pre-implementation (phase 1), eAlert implementation with CME (phase 2), and post-implementation without CME (phase3). The rates of thromboprophylaxis in the intervention group were 43.4% in phase 1 and 66.7% in phase 2 ($p<0.001$), and increased further to 73.6% in phase3 ($p=0.011$). Early thromboprophylaxis orders within 12 hours after admission were more often placed in phase 2 and 3 as compared to phase 1 (67.1% vs. 52.1%, $p<0.001$). In the surgical control group, the thromboprophylaxis rates in the three phases were 88.6%, 90.7%, 90.6% ($p=0.16$). Advanced eAlerts may provide sustained efficacy over time, with stable rates of thromboprophylaxis orders among hospitalised medical patients.

Colpaert K, Claus B, Somers A, Vandewoude K, Robays H, Decruyenaere J. **Impact of computerized physician order entry on medication prescription errors in the intensive care unit: a controlled cross-sectional trial**. Crit Care 2006;10(1):R21.

Abstract: INTRODUCTION: Medication errors in the intensive care unit (ICU) are frequent and lead to attributable patient morbidity and mortality, increased length of ICU stay and substantial extra costs. We investigated if the introduction of a computerized ICU system (Centricity Critical Care Clinisoft, GE Healthcare) reduced the incidence and severity of medication prescription errors (MPEs)., METHODS: A prospective trial was conducted in a paper-based unit (PB-U) versus a computerized unit (C-U) in a 22-bed ICU of a tertiary university hospital. Every medication order and medication prescription error was validated by a clinical pharmacist. The registration of different classes of MPE was done according to the National Coordinating Council for Medication Error Reporting and Prevention guidelines. An independent panel evaluated the severity of MPEs. We identified three groups: minor MPEs (no potential to cause harm); intercepted MPEs (potential to cause harm but intercepted on time); and serious MPEs (non-intercepted potential adverse drug events (ADE) or ADEs, being MPEs with potential to cause, or actually causing, patient harm)., RESULTS: The C-U and the PB-U each contained 80 patient-days, and a total of 2,510 medication prescriptions were evaluated. The clinical pharmacist identified 375 MPEs. The incidence of MPEs was significantly lower in the C-U compared with the PB-U (44/1286 (3.4%) versus 331/1224 (27.0%); $P < 0.001$). There were significantly less minor MPEs in the C-U than in the PB-U (9 versus 225; $P < 0.001$). Intercepted MPEs were also lower in the C-U (12 versus 46; $P < 0.001$), as well as the non-intercepted potential ADEs (21 versus 48; $P < 0.001$). There was also a reduction of ADEs (2 in the C-U versus 12 in the PB-U; $P < 0.01$). No fatal errors occurred. The most frequent drug classes involved were cardiovascular medication and antibiotics in both groups. Patients with renal failure experienced less dosing errors in the C-U versus the PB-U (12 versus 35 serious MPEs; $P < 0.001$)., CONCLUSION: The ICU computerization, including the medication order entry, resulted in a significant decrease in the occurrence and severity of medication errors in the ICU.

Cunningham TR, Geller ES, Clarke SW. **Impact of electronic prescribing in a hospital setting: a process-focused evaluation**. Int J Med Inform 2008;77(8):546-554.

Abstract: OBJECTIVE: To evaluate effects of a natural CPOE implementation in a hospital setting and inform the efficacy of using CPOE rather than traditional paper medication orders., DESIGN: A multiple-baseline, quasi-experimental study of a naturally occurring CPOE intervention, with a non-equivalent control site., MEASUREMENTS: Compliance with medication-ordering protocols and time to first dose of antibiotics., RESULTS: Medication orders placed using CPOE were significantly more compliant than paper-based medication orders, and first doses of antibiotics were delivered significantly faster when ordered with CPOE than when placed using the standard paper-based system ($p<.01$)., CONCLUSION:

Findings support the use of CPOE and justify the need for interventions to increase CPOE adoption and consistent use among physicians.

Davis L, Brunetti L, Lee E-K, Yoon N, Cho S-H, Suh D-C. **Effects of computerized physician order entry on medication turnaround time and orders requiring pharmacist intervention**. Research in social & administrative pharmacy : RSAP 2014;10(5):756-767.

Abstract: BACKGROUND: Previous studies have demonstrated that computerized physician order entry (CPOE) of prescriptions reduces both turnaround time (TAT) and medication errors. However, these studies have been performed primarily in large academic centers with a relatively small number of medication orders. As such, many studies investigating the impact of CPOE on the level of pharmacist intervention have yielded conflicting results., OBJECTIVE: The objective of this study was to examine the effects of CPOE on medication order TAT and the frequency of medication orders requiring pharmacist intervention in a community-based medical center., METHODS: A prospective cohort study was conducted at a community-based medical center. A total of 24,767 prescriptions written for 940 patients over a six-month period were stratified into CPOE or non-CPOE (handwritten) cohorts. TAT between cohorts were tested using analysis of variance and Tukey's Honestly Significant Difference test. The number of orders requiring pharmacist intervention was compared between cohorts and tested using chi-square test or Fisher's exact test. Medication orders requiring pharmacist intervention were stratified by patient characteristics, therapeutic class, and types of medication error., RESULTS: Medication orders not using CPOE were approximately 8 times more likely to require pharmacist intervention (2.26% versus 0.29%; $P < 0.001$), with the majority of pharmacist interventions performed to prevent medication errors. The overall mean TAT for medication orders was significantly shorter in the CPOE group in comparison with the non-CPOE group (22.2 +/- 86.5 min versus 81 +/- 256.7 min; $P < 0.001$). CPOE orders nearly eliminated medication errors with wrong dosage forms and formulary issues., CONCLUSIONS: Medication orders entered via CPOE are associated with a significant reduction in medication TAT and less likely to require pharmacist intervention. Use of CPOE may improve quality of patient care and efficiency of health care delivery.

Delgado Sanchez O, Escriva Torralva A, Vilanova Bolto M, Serrano Lopez De Las Hazas J, Crespi Monjo M, Pinteno Blanco M, et al. **Comparative study of errors in electronic versus manual prescription. [Spanish]**. Farmacia Hospitalaria 2005;29(4):228-235.

Abstract: Objective: Electronic prescribing is considered a basic measure for the prevention and reduction of medications errors. The goal of this survey was to assess the incidence of errors occurring with electronic versus standard prescription. Method: A prospective, sequential, open-label study to assess errors with electronic prescribing as compared to traditional manual prescribing in two public hospitals in Balearic Islands. Errors regarding medication, diet and/or nursing orders were assesses along four process stages: medical prescription, pharmacy transcription/validation, nursing transcription, and dispensation. Results: With manual prescription 1,576 errors/18,539 therapy orders (8.50%) were identified, whereas with electronic prescription 827 errors/18,885 therapy orders (4.38%) were detected, which represents a relative risk reduction by 48% and an absolute risk reduction by 4.12% ($p < 0.0001$). Pharmacy transcription/validation errors decreased (1.73 vs. 0.13%, $p < 0.0001$), as did nursing transcription errors (2.54 us. 0.81%, $p < 0.0001$) and dispensation errors (2.13 vs. 0.96%, $p < 0.0001$); however, the number of prescription errors increased (2.10 vs. 2.40%, $p = 0.0401$). Conclusions: Electronic prescription is a powerful tool, and one that in this work was shown to decrease medication-, diet-, and nursing care-related errors in a highly significant way; however, it should be developed and maintained in order to achieve safety and effectiveness as required by drug usage.

Groth-Tonberge C, Hackh G, Strehl E, Hug M. **Does computerized physician order entry (CPOE) improve medication safety?. [German]**. Krankenhauspharmazie 2012;33(11):476-479.

Abstract: It is generally assumed that computerized physician order entry (CPOE) significantly improves medication safety. However, recently conflicting results have been reported in the literature [1, 4, 5, 6]. Aim of the present study was to investigate the effect of the implementation of CPOE on the individual steps of the medication process. For this pur-

pose incomplete prescriptions and the number of deviations from the physician's prescription and specifications of the manufacturer were identified on two wards (ward A = handwritten prescription, ward B = computerized prescription). For this study only oral drugs were considered. Twelve criteria to judge the medication process have been included. On ward A a total of 1,155 and on ward B a total of 1,855 medications were checked. During the investigation we found 647 (56%) deviations on ward A and 720 (38,8%) on ward B. Differences regarding the identity of administered product and the physician's prescription were 10,4% on ward A versus 43,8% on ward B. Our study demonstrates that implementation of CPOE does generally decrease the number of medication errors caused by inaccurate prescription. The medication safety however is not increased necessarily.

Huertas Fernandez MJ, Baena-Canada JM, Martinez Bautista MJ, Arriola Arellano E, Garcia Palacios MV. **Impact of computerised chemotherapy prescriptions on the prevention of medication errors**. Clinical & translational oncology : official publication of the Federation of Spanish Oncology Societies and of the National Cancer Institute of Mexico 2006;8(11):821-825.

Abstract: OBJECTIVES: The authors sought to evaluate the impact of computerised chemotherapy prescription on the reduction of medication errors. The purpose of this study was to assess the incidence of errors present in electronic versus manual prescription., MATERIAL AND METHODS: The data gathered from computerised chemotherapy prescription sheets were submitted to a prospective analysis as cases of the intervention groups. The control group was comprised of the handwritten chemotherapy prescription sheets. Chemotherapy prescriptions for consecutive oncology patients were analysed by 2 independent examiners, who investigated errors of omission, commission, interpretation of dates, abbreviations and illegible handwriting. The proportion of treatment prescriptions containing one or more errors and the median of errors were calculated in order in both groups., RESULTS: At least one error was detected in 100% of the manual prescriptions and in 13% of computerised prescriptions ($p < 0.001$). The median of errors per computerised prescription was 0 (range: 0-1), whereas in manual prescriptions the median was 5 (range: 1-12) ($p < 0.001$). Errors of omission were predominant in manual prescriptions. Errors of commission were limited to 1 case of unjustified cytostatic agent infra-dosage in a computerised prescription. This error was present in 3 cases in handwritten prescriptions and, in addition, 1 case of premedication drug substitution was detected. Errors of interpretation of the date, use of abbreviations and illegible handwriting were frequent among manual prescriptions and were absent from computerised prescriptions., CONCLUSIONS: Electronic chemotherapy prescription is a powerful tool. In this study it has been shown to decrease chemotherapy-related medication errors and ensure that safe chemotherapy practices were followed.

King WJ, Paice N, Rangrej J, Forestell GJ, Swartz R. **The effect of computerized physician order entry on medication errors and adverse drug events in pediatric inpatients**. Pediatrics 2003;112(3 Pt 1):506-509.

Abstract: OBJECTIVE: Computerized physician order entry (CPOE) has the potential to reduce patient injury resulting from medication errors. We assessed the impact of a CPOE system on medication errors and adverse drug events (ADEs) in pediatric inpatients., DESIGN: A retrospective cohort study., SETTING: Tertiary care pediatric hospital., PARTICIPANTS: Pediatric inpatients on 3 medical and 2 surgical wards., INTERVENTION: CPOE system implemented on 2 medical wards and compared with 1 medical and 2 surgical wards that continued to use hand written orders., OUTCOME MEASURES: Rate of medication error and ADEs before and after CPOE implementation., RESULTS: In 6 years, a total of 804 medication errors were identified with 18 ADEs, resulting in patient injury among 36 103 discharges and 179 183 patient days. The overall medication error rate (MER) was 4.49 per 1000 patient days. Before the introduction of CPOE, the MERs of the intervention versus control wards were indistinguishable (ratio = 0.93; 95% confidence interval [CI] = 0.76, 1.13). After the introduction of CPOE, the MER was 40% lower on the intervention than on the control wards (ratio = 0.60; 95% CI = 0.48, 0.74). On average, 490 patient days are required to see the benefit of one less medication error using CPOE. We did not demonstrate a similar effect of CPOE for ADEs (ratio of rate ratios = 1.30; 95% CI 0.47, 3.52)., CONCLUSIONS: The introduction of a commercially available physician computer order entry system was associated with a significant decrease in the rate of medication errors but not ADEs in an inpatient pediatric population.

Lopez Sanchez P, Heredia Benito M, Jerez Fernandez E, Seisdedos Elcuaz R, Ruiz Martin De La Torre R, Conde Garcia MC, et al. **Dispensing error rate in a tertiary hospital**. European Journal of Hospital Pharmacy: Science and Practice 2012;19 (2):122-123.

Abstract: Background: The ward drug trolley process is error-prone so therefore pharmacists should take measure to recognise and prevent them. Purpose: To evaluate the rates and types of dispensing errors (DE) during the drug trolley process. Materials and methods: Prospective observational study. Data were collected for 44 working days in 2009 and 2010. The hospital had 350 beds with seven medical and four surgical wards. 84.3% of beds use a unit-dose dispensing system (UDDS) plus written transcription (UDDS-WT) and 15.7% use UDDS plus computerised prescription order entry (UDDS-CPOE). Each day pharmacists randomly selected one or two trolleys and checked them. Dispensing errors were classified as: Type 1: wrong patient, Type 2: omission of drug, Type 3: drug not prescribed, Type 4: Wrong dose, route or dosage form and Type 5: Quantity error. The authors calculated the dispensing error rate (DER) by dividing DE by the opportunities for error (OE: total units dispensed+doses prepared in the drug trolleys). Results: The observations were conducted on 56 drug trolleys (1928 beds): 36 medical and 20 surgical, 14 428 total of doses prepared and dispensed (OE). 137 DEs were detected: 1.46% (2) type 1, 40.15% (55) type 2, 32.17% (44) type 3, 13.14% (18) type 4 and 13.14% (18) type 5. The most frequent errors are type 2 and type 3, related to the prescription changes after the drug trolley process. The DE rate was 0.95% (137 of 14,428). The DE rate in UDDS-WT was 0.91% (117 of 12868) and in UDDS-CPOE it was 1.28% (20 of 1560). Conclusions The short period of our study and the great difference in the methodology used in other studies hinder the comparison with their results. Although there are almost no differences between our DE rate in the two modalities of dispensing, it was not possible to compare them as the OE varied substantially. Despite the fact that the DE rate was low, recognising the incidence and types of medication errors allows us to analyse the causes to help achieve maximum patient safety.

Mattsson TO, Holm B, Michelsen H, Knudsen JL, Brixen K, Herrstedt J. **Non-intercepted dose errors in prescribing anti-neoplastic treatment: A prospective, comparative cohort study**. Ann Oncol 2015;26(5):981-986.

Abstract: Background: The incidence of non-intercepted prescription errors and the risk factors involved, including the impact of computerised order entry (CPOE) systems on such errors, are unknown. Our objective was to determine the incidence, type, severity, and related risk factors of non-intercepted prescription dose errors. Patients and methods: A prospective, comparative cohort study in two clinical oncology units. One institution used a CPOE system with no connection to the electronic patient record system, while the other used paper-based prescription forms. All standard prescriptions were included and reviewed. Doses were recalculated according to the guidelines of each institution, using the patient data as documented in the patient record, the paper-based prescription form, or the CPOE system. A non-intercepted prescription dose error was defined as >10% difference between the administered and the recalculated dose. Results: Data were collected from 1 November 2012 to 15 January 2013. A total of 5767 prescriptions were evaluated, 2677 from the institution using CPOE and 3090 from the institution with paper-based prescription. Crude analysis showed an overall risk of a prescription dose error of 1.73 per 100 prescriptions. CPOE resulted in 1.60 and paper-based prescription forms in 1.84 errors per 100 prescriptions, i.e. odds ratio (OR) = 0.87 [95% confidence interval (CI) 0.59- 1.29, P = 0.49]. Fifteen different types of errors and four potential risk factors were identified. None of the dose errors resulted in the death of the patient. Conclusion(s): Non-intercepted prescribing dose errors occurred in <2% of the prescriptions. The parallel CPOE system did not significantly reduce the overall risk of dose errors, and although it reduced the risk of calculation errors, it introduced other errors. Strategies to prevent future prescription errors could usefully focus on integrated computerised systems that can aid dose calculations and reduce transcription errors between databases.

Mattsson TO, Holm B, Michelsen HM, Knudsen JL, Brixen K, Herrstedt J. **Prevalence of prescribing errors resulting in administration of incorrect dosages of antineoplastic treatment**. J Clin Oncol 2014;1).

Abstract: Background: The prevalence of non-intercepted prescribing errors and the impact of computerized order entry systems (CPOE) in preventing such errors are not known. Our objective was to evaluate both prevalence and severity of non-intercepted prescription dose errors as well as the impact of a CPOE system on these in a setting of adult

cancer patients. Methods: A prospective observational case control study in two clinical oncology units. One institution used a parallel CPOE system with no connection to the electronic patient chart data, while the other used paper based prescription forms. All standard prescriptions from both institutions were included and reviewed. Doses were recalculated according to the guidelines of each of the institutions using the patient data as documented in the chart, on the paper based form or in the CPOE system at the time of prescription. A non-intercepted prescription dose error was defined as > 10% difference between the administered and the recalculated dose. Main outcome measures were prevalence and severity of prescription errors using validated harm categories. Results: Data were collected from November 1, 2012 til January 31, 2013. A total of 5,767 physician prescriptions were evaluated. 2,677 from the institution using CPOE and 3090 from the institution with paper based prescription forms. Crude analysis showed an overall risk of a prescription dose error of 1.73 per 100 prescriptions. CPOE resulted in 1.60 and paper based prescription forms in 1.84 errors per 100 prescriptions. OR = 0.87 (95%CI 0.59-1.29, P=0.49). Furthermore, no significant difference between institutions in severity of errors was observed. Conclusions: Non-intercepted prescribing dose errors are relatively common in clinical oncology units. Non integrated CPOE systems without decision support do not seem to significantly reduce the risk of prescription errors or affect severity of errors. Based on the results of this study strategies to prevent future prescription errors are highly warranted.

Oliven A, Michalake I, Zalman D, Dorman E, Yeshurun D, Odeh M. **Prevention of prescription errors by computerized, on-line surveillance of drug order entry**. Int J Med Inform 2005;74(5):377-386.

Abstract: Aims: The present study was undertaken to quantify the impact of computerized drug order entry system (CDOE) connected to the patients' database, on the incidence and type of prescription errors (PEs) in the medical service, and to delineate the causes for remaining errors. Methods: Drug orders were reviewed daily by a physician-reviewer, in a department of internal medicine that used for more than 3 years a CDOE (CDOEdept), and in a similar department in which drug orders were handwritten (HWdept). PEs were divided into those not related to the individual patient (type 1 PEs), and PEs resulting from drug-laboratory, drug-disease, and drug-allergy interactions (type 2 PEs). Results: Ten thousand and two hospitalization days were evaluated. The incidence of type 1 PEs was 5.21 and 1.36 per 100 hospitalization days in the HWdept and CDOEdept, respectively ($p < 0.0001$). Type 2 PEs were more common, 7.20 and 3.02 per 100 hospitalization days in the HWdept and CDOEdept, respectively ($p < 0.0001$), and about 75% of them were due to few drug-laboratory interactions. Most of the remaining errors in the CDOEdept were due to inadequate adjustment of drugs and doses to renal function, or failure to perform adequate changes when new laboratory results became available. Conclusions: We conclude that linking the CDOE with few, specific, laboratory results has a large impact on the prevention of PEs. Combining the CDOE with a drug-laboratory alert system is expected to further reduce the incidence of PEs.

Riaz MK, Hashmi FK, Bukhari NI, Riaz M, Hussain K. **Occurrence of medication errors and comparison of manual and computerized prescription systems in public sector hospitals in Lahore, Pakistan**. PLoS One 2014;9(8).

Abstract: The knowledge of medication errors is an essential prerequisite for better healthcare delivery. The present study investigated prescribing errors in prescriptions from outpatient departments (OPDs) and emergency wards of two public sector hospitals in Lahore, Pakistan. A manual prescription system was followed in Hospital A. Hospital B was running a semi-computerised prescription system in the OPD and a fully computerised prescription system in the emergency ward. A total of 510 prescriptions from both departments of these two hospitals were evaluated for patient characteristics, demographics and medication errors. The data was analysed using a chi square test for comparison of errors between both the hospitals. The medical departments in OPDs of both hospitals were the highest prescribers at 45%-60%. The age group receiving the most treatment in emergency wards of both the hospitals was 21-30 years (21%-24%). A trend of omitting patient addresses and diagnoses was observed in almost all prescriptions from both of the hospitals. Nevertheless, patient information such as name, age, gender and legibility of the prescriber's signature were found in almost 100% of the electronic-prescriptions. In addition, no prescribing error was found pertaining to drug concentrations, quantity and rate of administration in e-prescriptions. The total prescribing errors in the OPD and emergency ward of Hospital A were found to be 44% and 60%, respectively. In hospital B, the OPD had 39% medication errors

and the emergency department had 73.5% errors; this unexpected difference between the emergency ward and OPD of hospital B was mainly due to the inclusion of 69.4% omissions of route of administration in the prescriptions. The incidence of prescription overdose was approximately 7%-19% in the manual system and approximately 8% in semi and fully electronic system. The omission of information and incomplete information are contributors of prescribing errors in both manual and electronic prescriptions. © 2014 Riaz et al.

Syed S, Wang D, Goulard D, Rich T, Innes G, Lang E. **Computer order entry systems in the emergency department significantly reduce the time to medication delivery for high acuity patients**. Int J Emerg Med 2013;6(1):20.

Abstract: BACKGROUND: Computerized physician order entry (CPOE) systems are designed to increase safety and improve quality of care; however, their impact on efficiency in the ED has not yet been validated. This study examined the impact of CPOE on process times for medication delivery, laboratory utilization and diagnostic imaging in the early, late and control phases of a regional ED-CPOE implementation., METHODS:, SETTING: Three tertiary care hospitals serving a population in excess of 1 million inhabitants that initiated the same CPOE system during the same 3-week time window. Patients were stratified into three groupings: Control, Early CPOE and Late CPOE (n = 200 patients per group/hospital site). Eligible patients consisted of a stratified (40% CTAS 2 and 60% CTAS 3) random sample of all patients seen 30 days preceding CPOE implementation (Control), 30 days immediately after CPOE implementation (Early CPOE) and 5-6 months after CPOE implementation (Late CPOE). Primary outcomes were time to (TT) from physician assignment (MD-sign) up to MD-order completion. An ANOVA and t-test were employed for statistical analysis., RESULTS: In comparison with control, TT 1st MD-Ordered Medication decreased in both the Early and Late CPOE groups (102.6 min control, 62.8 Early and 65.7 late, $p < 0.001$). TT 1st MD-ordered laboratory results increased in both the Early and Late CPOE groups compared to Control (76.4, 85.3 and 73.8 min, respectively, $p < 0.001$). TT 1st X-Ray also significantly increased in both the Early and Late CPOE groups (80.4, 84.8 min, respectively, compared to 68.1, $p < 0.001$). Given that CT and ultrasound imaging inherently takes increased time, these imaging studies were not included, and only X-ray was examined. There was no statistical difference found between TT discharge and consult request., CONCLUSIONS: Regional implementation of CPOE afforded important efficiencies in time to medication delivery for high acuity ED patients. Increased times observed for laboratory and radiology results may reflect system issues outside of the emergency department and as a result of potential confounding may not be a reflection of CPOE impact.

Yu F, Salas M, Kim YI, Menachemi N. **The relationship between computerized physician order entry and pediatric adverse drug events: A nested matched case-control study**. Pharmacoepidemiol Drug Saf 2009;18(8):751-755.

Abstract: This study assesses the impact of computerized physician order entry (CPOE) implementation in pediatric hospitals on reported adverse drug events. Using a nested matched case-control design; we linked CPOE implementation information from the health information management systems society analytics database with reported adverse drug event (ADE) from the national association of children's hospitals and related institutions case mix comparative data program. Differences were examined using univariate and multivariate conditional logistic regression analyses. Patients from CPOE hospitals were more frequently seen in larger hospitals have more co-morbidities than those from non-CPOE hospitals. When matched by admitting diagnosis, age, gender and race, ADE cases were associated with more reported co-morbidities, and were reported less frequently in hospitals with CPOE. Patients from hospitals without CPOE were 42% more likely to experience reportable ADE after adjusting for the presence of co-morbidities. In conclusion, we found significant beneficial associations between reportable ADE and CPOE adoption in a representative sample of pediatric hospitals. Copyright © 2009 John Wiley & Sons, Ltd.

Elektroniske alarmsystemer (alerts)
RCT

Adelman JS, Kalkut GE, Schechter CB, Weiss JM, Berger MA, Reissman SH, et al. **Understanding and preventing wrong-patient electronic orders: a randomized controlled trial**. Journal of the American Medical Informatics Association : JAMIA 2013;20(2):305-310.

Abstract: OBJECTIVE: To evaluate systems for estimating and preventing wrong-patient electronic orders in computerized physician order entry systems with a two-phase

study., MATERIALS AND METHODS: In phase 1, from May to August 2010, the effectiveness of a 'retract-and-reorder' measurement tool was assessed that identified orders placed on a patient, promptly retracted, and then reordered by the same provider on a different patient as a marker for wrong-patient electronic orders. This tool was then used to estimate the frequency of wrong-patient electronic orders in four hospitals in 2009. In phase 2, from December 2010 to June 2011, a three-armed randomized controlled trial was conducted to evaluate the efficacy of two distinct interventions aimed at preventing these errors by reverifying patient identification: an 'ID-verify alert', and an 'ID-reentry function'., RESULTS: The retract-and-reorder measurement tool effectively identified 170 of 223 events as wrong-patient electronic orders, resulting in a positive predictive value of 76.2% (95% CI 70.6% to 81.9%). Using this tool it was estimated that 5246 electronic orders were placed on wrong patients in 2009. In phase 2, 901 776 ordering sessions among 4028 providers were examined. Compared with control, the ID-verify alert reduced the odds of a retract-and-reorder event (OR 0.84, 95% CI 0.72 to 0.98), but the ID-reentry function reduced the odds by a larger magnitude (OR 0.60, 95% CI 0.50 to 0.71)., DISCUSSION AND CONCLUSION: Wrong-patient electronic orders occur frequently with computerized provider order entry systems, and electronic interventions can reduce the risk of these errors occurring.

Bhardwaja B, Carroll NM, Raebel MA, Chester EA, Korner EJ, Rocho BE, et al. **Improving prescribing safety in patients with renal insufficiency in the ambulatory setting: the Drug Renal Alert Pharmacy (DRAP) program**. Pharmacotherapy 2011;31(4):346-356.

Abstract: STUDY OBJECTIVE: To determine whether a computerized Drug Renal Alert Pharmacy (DRAP) program could decrease the rate of medication errors in drug selection or dosing for 15 target drugs in patients with renal insufficiency., DESIGN: Randomized, controlled, population-based effectiveness trial., SETTING: A large integrated health care delivery system., PATIENTS: A total of 32,917 health plan members who were at least 18 years old, had an estimated creatinine clearance of 50 ml/minute or lower, and were not receiving dialysis between December 1, 2003, and February 28, 2005, were randomly assigned to either the intervention group (16,577 patients) or usual care (control) group (16,340 patients). Of the 32,917 patients, 6125 patients (3025 in the intervention group and 3100 in the usual care group) were prescribed at least one target drug and were included in the analysis., INTERVENTION: A computerized tool--the DRAP program--was used to alert pharmacists at the time of dispensing to possible errors in target drug selection and dosing for patients with renal insufficiency. The 15 target drugs were previously identified based on frequency of use in our health care system and risk of serious adverse events., MEASUREMENTS AND MAIN RESULTS: The primary outcome was the proportion of medication errors, defined as target drugs that should be avoided or were dosed inappropriately, in the intervention and usual care groups. The Reach, Effectiveness, Adoption, Implementation, Maintenance (RE-AIM) framework was used to evaluate the intervention's potential for translation and generalizability. Among the 6125 patients who received a target drug, no significant differences were noted in age, sex, creatinine clearance, comorbid conditions, and number of target drugs between groups at baseline. Over the 15-month intervention period, the proportion of medication errors was significantly lower in the intervention group than the usual care group (33% vs 49%, $p<0.001$). After the study period, when the intervention was expanded to both groups, a 20% reduction in errors was sustained in the combined groups over the subsequent 7 months., CONCLUSION: The DRAP program was successful in reducing medication errors for patients with renal insufficiency in an ambulatory setting and was demonstrated to have sustainability after study completion.

Duke JD, Li X, Dexter P. **Adherence to drug-drug interaction alerts in high-risk patients: a trial of context-enhanced alerting**. Journal of the American Medical Informatics Association : JAMIA 2013;20(3):494-498.

Abstract: OBJECTIVE: Drug-drug interaction (DDI) alerting is an important form of clinical decision support, yet physicians often fail to attend to critical DDI warnings due to alert fatigue. We previously described a model for highlighting patients at high risk of a DDI by enhancing alerts with relevant laboratory data. We sought to evaluate the effect of this model on alert adherence in high-risk patients., METHODS: A 6-month randomized controlled trial involving 1029 outpatient physicians was performed. The target interactions were all DDIs known to cause hyperkalemia. Alerts in the intervention group were enhanced with the patient's most recent potassium and creatinine levels. The control group received unmodified alerts. High -risk patients were those with baseline potassium >5.0 mEq/l

and/or creatinine >1.5 mg/dl (132 mumol/l)., RESULTS: We found no significant difference in alert adherence in high-risk patients between the intervention group (15.3%) and the control group (16.8%) (p=0.71). Adherence in normal risk patients was significantly lower in the intervention group (14.6%) than in the control group (18.6%) (p<0.01). In neither group did physicians increase adherence in patients at high risk., CONCLUSIONS: Physicians adhere poorly to hyperkalemia-associated DDI alerts even in patients with risk factors for a clinically significant interaction, and the display of relevant laboratory data in these alerts did not improve adherence levels in the outpatient setting. Further research is necessary to determine optimal strategies for conveying patient-specific DDI risk.

Palen TE, Raebel M, Lyons E, Magid DM. **Evaluation of laboratory monitoring alerts within a computerized physician order entry system for medication orders**. The American journal of managed care 2006;12(7):389-395.

Abstract: BACKGROUND: Errors involving medication use are common. Computerized physician order entry (CPOE) can improve prescribing practices. Few studies have examined the effect of CPOE in combination with decision support tools on prescribing practices in the outpatient setting. Less is known about prescribers' adherence to laboratory monitoring recommendations., OBJECTIVE: To evaluate if reminders presented during CPOE for medications would increase physicians' compliance with guidelines for laboratory monitoring at initiation of therapy., STUDY DESIGN: Randomized prospective intervention study., METHODS: Two hundred seven primary care physicians in a group-model managed care organization were randomized to receive or not receive drug laboratory monitoring alerts within the CPOE system. Adherence to laboratory monitoring recommendations for patients prescribed selected medications was compared between physician groups., RESULTS: There was no significant difference between the control and intervention group physicians in the overall rate of compliance with ordering the recommended laboratory monitoring for patients prescribed study medications. Laboratory monitoring was performed as recommended 56.6% of the time in the intervention group compared with 57.1% of the time in the control group (P = .31). In cases in which a statistically significant difference was demonstrated, improved compliance favored the intervention group (eg, 71.2% vs 62.3% [P = .003] for gemfibrozil and 75.7% vs 73.9% [P = .05] for statins)., CONCLUSIONS: As CPOE becomes more prevalent, additional research is needed to determine effective decision support tools. These findings then should be communicated to the developers and users of computerized medical record systems.

Raebel MA, Charles J, Dugan J, Carroll NM, Korner EJ, Brand DW, et al. **Randomized trial to improve prescribing safety in ambulatory elderly patients**. J Am Geriatr Soc 2007;55(7):977-985.

Abstract: OBJECTIVES: To determine whether a computerized tool that alerted pharmacists when patients aged 65 and older were newly prescribed potentially inappropriate medications was effective in decreasing the proportion of patients dispensed these medications., DESIGN: Prospective, randomized trial., SETTING: U.S. health maintenance organization., PARTICIPANTS: All 59,680 health plan members aged 65 and older were randomized to intervention (n=29,840) or usual care (n=29,840). Pharmacists received alerts on all patients randomized to intervention who were newly prescribed a targeted medication., INTERVENTION: Prescription and age information were linked to alert pharmacists when a patient aged 65 and older was newly prescribed one of 11 medications that are potentially inappropriate in older people., MEASUREMENTS: Physicians and pharmacists collaborated to develop the targeted medication list, indications for medication use for which an intervention should occur, intervention guidelines and scripts, and to implement the intervention., RESULTS: Over the 1-year study, 543 (1.8%) intervention group patients aged 65 and older were newly dispensed prescriptions for targeted medications, compared with 644 (2.2%) usual care group patients (P=.002). For medication use indications in which an intervention should occur, dispensings of amitriptyline (P<.001) and diazepam (P=.02) were reduced., CONCLUSIONS: This study demonstrated the effectiveness of a computerized pharmacy alert system plus collaboration between healthcare professionals in decreasing potentially inappropriate medication dispensings in elderly patients. Coupling data available from information systems with the knowledge and skills of physicians and pharmacists can improve prescribing safety in patients aged 65 and older.

Redwood S, Ngwenya NB, Hodson J, Ferner RE, Coleman JJ. **Effects of a computerized feedback intervention on safety performance by junior doctors: results from a randomized mixed method study**. BMC Med Inform Decis Mak 2013;13:63.

Abstract: BACKGROUND: The behaviour of doctors and their responses to warnings can inform the effective design of Clinical Decision Support Systems. We used data from a University hospital electronic prescribing and laboratory reporting system with hierarchical warnings and alerts to explore junior doctors' behaviour. The objective of this trial was to establish whether a Junior Doctor Dashboard providing feedback on prescription warning information and laboratory alerting acceptance rates was effective in changing junior doctors' behaviour., METHODS: A mixed methods approach was employed which included a parallel group randomised controlled trial, and individual and focus group interviews. Junior doctors below the specialty trainee level 3 grade were recruited and randomised to two groups. Every doctor (N=42) in the intervention group was e-mailed a link to a personal dashboard every week for 4 months. Nineteen participated in interviews. The 44 control doctors did not receive any automated feedback. The outcome measures were the difference in responses to prescribing warnings (of two severities) and laboratory alerting (of two severities) between the months before and the months during the intervention, analysed as the difference in performance between the intervention and the control groups., RESULTS: No significant differences were observed in the rates of generating prescription warnings, or in the acceptance of laboratory alarms. However, responses to laboratory alerts differed between the pre-intervention and intervention periods. For the doctors of Foundation Year 1 grade, this improvement was significantly (p=0.002) greater in the group with access to the dashboard (53.6% ignored pre-intervention compared to 29.2% post intervention) than in the control group (47.9% ignored pre-intervention compared to 47.0% post intervention). Qualitative interview data indicated that while junior doctors were positive about the electronic prescribing functions, they were discriminating in the way they responded to other alerts and warnings given that from their perspective these were not always immediately clinically relevant or within the scope of their responsibility., CONCLUSIONS: We have only been able to provide weak evidence that a clinical dashboard providing individualized feedback data has the potential to improve safety behaviour and only in one of several domains. The construction of metrics used in clinical dashboards must take account of actual work processes., TRIAL REGISTRATION ISRCTN: ISRCTN72253051.

Controlled trial

Garcia DA, Highfill J, Finnerty K, Varoz E, McConkey S, Hutchinson K, et al. **A prospective, controlled trial of a pharmacy-driven alert system to increase thromboprophylaxis rates in medical inpatients**. Blood coagulation & fibrinolysis : an international journal in haemostasis and thrombosis 2009;20(7):541-545.

Abstract: Although venous thromboembolism is an important cause of morbidity and mortality within the hospital, a significant proportion of at-risk inpatients do not receive measures known to reduce the risk of deep vein thrombosis and pulmonary embolism. The objective of the present study was to determine whether a pharmacy-driven alert system would, compared to usual care, be associated with a higher rate of adequate venous thromboembolism prevention measures among at-risk inpatients on a general internal medicine service. The study was a prospective, controlled trial set at a university-based teaching hospital. The participants were adults who were admitted (Monday through Friday) to the general internal medicine inpatient service from 19 June to 21 September 2006. Their treatment included a pharmacist assessment of venous thromboembolism risk and a pharmacist-driven alert to the treating physician. The Proportion of at-risk patients receiving adequate thromboprophylaxis within 36 h of admission was recorded. Overall, 140 patients were at sufficient risk for venous thromboembolism to be included. In the usual care group, prophylactic measures were ordered for 49 (61%) of the 80 patients at moderate to high risk. In the pharmacist-alert group, 44 (73%) of the 60 moderate to high venous thromboembolism-risk patients received adequate thromboprophylaxis (P = 0.15). Although we did not observe a statistically significant difference between the groups, our results are consistent with previous reports suggesting that alert systems can increase the proportion of hospitalized patients who receive adequate measures to prevent venous thromboembolism.

ITS

Bambauer KZ, Adams AS, Zhang F, Minkoff N, Grande A, Weisblatt R, et al. **Physician alerts to increase antidepressant adherence: fax or fiction?** Arch Intern Med 2006;166(5):498-504.

Abstract: BACKGROUND: Many managed care organizations use feedback based on electronically maintained claims data to alert physicians to potential treatment problems, including patient medication nonadherence. However, the efficacy of such interventions for improving adherence among patients treated for depression is unknown., METHODS: We examined an antidepressant compliance program consisting of faxed alerts to physicians beginning May 2003 using interrupted time series analysis to evaluate its impact on rates of antidepressant adherence between May 2002 and May 2004 among members of the managed care plan of Harvard Pilgrim Health Care, which is a health plan operating in 3 states in New England, with corporate headquarters in Wellesley, Mass. The program alerted prescribing physicians to patients with gaps of more than 10 days in refilling antidepressant prescriptions during the first 180 days of treatment. Our outcome measures were rates of nonadherence among patients with refill gaps of more than 10 days ("delayed refill") and proportion of days without treatment within the first 180 days of treatment., RESULTS: A total of 13 128 patients (> or = 18 years of age) who were starting treatment with antidepressants met the study criteria. Rates of nonadherence among patients with delayed refills remained constant (P = .22) over the 2-year study period, averaging 75% (95% confidence interval, 72.7%-77.3%). Rates of antidepressant nonadherence significantly increased over time (P = .04), with an average of 40% (95% confidence interval, 38.4%-41.6%) of days without dispensed antidepressants available during treatment episodes., CONCLUSIONS: Using real-time pharmacy information to alert physicians regarding patient adherence was not successful in increasing antidepressant adherence rates among members of the managed care plan. Effectiveness of electronically triggered, patient-specific, faxed feedback should be carefully evaluated before widespread implementation, because faxes are insufficient as a stand-alone policy tool.

Humphries TL, Carroll N, Chester EA, Magid D, Rocho B. **Evaluation of an electronic critical drug interaction program coupled with active pharmacist intervention**. The Annals of pharmacotherapy 2007;41(12):1979-1985.

Abstract: BACKGROUND: Failure to detect significant drug interactions may result in adverse outcomes. While proper screening and management of drug interactions can prevent the majority of adverse events, studies indicate that current practice is suboptimal. In the last quarter of 2001, physicians and pharmacists in Kaiser Permanente Colorado, a group model health maintenance organization, developed an electronic critical drug interaction alert program (CDIX). Electronic screening was coupled with active intervention to prevent dispensing of critically interacting drug combinations., OBJECTIVE: To assess the impact of CDIX on the co-dispensing of critically interacting drug combinations., METHODS: A physician and team of outpatient pharmacists and clinical pharmacy staff developed a condensed list of critical drug interactions (8 drug combinations) to be included in the evaluation of CDIX. Monthly electronic outpatient pharmacy data were collected 20 months before and 37 months after CDIX implementation, with no lag period following implementation. Univariate analyses were completed to compare baseline subject characteristics of the pre- and post-CDIX groups using chi2 and Wilcoxon Rank Sum tests. Interrupted time series analysis was used to estimate changes in the rates of critical drug interactions., RESULTS: Three hundred sixty-seven instances of co-dispensing were observed in 348 subjects during the pre-CDIX period and 256 instances of co-dispensing were observed in 248 subjects during the post-CDIX period. Following CDIX implementation, the overall rate of co-dispensing dropped abruptly from 21.3 to 14.7 per 10,000 prescriptions, representing a relative decrease in co-dispensing of 31% from the month before CDIX implementation (p = 0.0125). Significant reductions in co-dispensing were noted for 7 of the 8 drug class combinations., CONCLUSIONS: Employing an intervention system that limits electronic alerts regarding drug interactions to those deemed critical but that also requires pharmacist intervention and collaboration with the prescriber decreases the number of critical drug interactions dispensed.

Saxena K, Lung BR, Becker JR. **Improving patient safety by modifying provider ordering behavior using alerts (CDSS) in CPOE system**. AMIA Annual Symposium proceedings / AMIA Symposium AMIA Symposium 2011;2011:1207-1216.

Abstract: Medication errors are not unusual in acute care settings. This prospective time series analysis/study evaluates the use of Clinical Decision Support System (CDSS)/alerts in helping providers not to make errors, when putting in orders in a CPOE system. We reviewed electronic health records for all the inpatients coming to 5 community hospitals for a 6 months duration (July 2010 - December 2010). Responses to 9 synchronous alerts (CDSS tools) were studied, that were prompted on computer screens when providers

were putting in medication orders in EMR. These alerts guided the providers regarding any drug duplications, interactions, contraindications of the prescribed medicine with patient's clinical condition etc. The CDSS system in place changed the physician behavior & patient therapy 41.75% of the times when medication orders were placed. These alerts substantially decreased the medication error rate/adverse drug events (ADE's) in the patients receiving care at these 5 hospitals.

Simpao AF, Ahumada LM, Desai BR, Bonafide CP, Galvez JA, Rehman MA, et al. **Optimization of drug-drug interaction alert rules in a pediatric hospital's electronic health record system using a visual analytics dashboard**. Journal of the American Medical Informatics Association : JAMIA 2015;22(2):361-369.

Abstract: OBJECTIVE: To develop and evaluate an electronic dashboard of hospital-wide electronic health record medication alerts for an alert fatigue reduction quality improvement project., METHODS: We used visual analytics software to develop the dashboard. We collaborated with the hospital-wide Clinical Decision Support committee to perform three interventions successively deactivating clinically irrelevant drug-drug interaction (DDI) alert rules. We analyzed the impact of the interventions on care providers' and pharmacists' alert and override rates using an interrupted time series framework with piecewise regression., RESULTS: We evaluated 2 391 880 medication alerts between January 31, 2011 and January 26, 2014. For pharmacists, the median alert rate prior to the first DDI deactivation was 58.74 alerts/100 orders (IQR 54.98-60.48) and 25.11 alerts/100 orders (IQR 23.45-26.57) following the three interventions ($p<0.001$). For providers, baseline median alert rate prior to the first round of DDI deactivation was 19.73 alerts/100 orders (IQR 18.66-20.24) and 15.11 alerts/100 orders (IQR 14.44-15.49) following the three interventions ($p<0.001$). In a subgroup analysis, we observed a decrease in pharmacists' override rates for DDI alerts that were not modified in the system from a median of 93.06 overrides/100 alerts (IQR 91.96-94.33) to 85.68 overrides/100 alerts (IQR 84.29-87.15, $p<0.001$). The medication serious safety event rate decreased during the study period, and there were no serious safety events reported in association with the deactivated alert rules., CONCLUSIONS: An alert dashboard facilitated safe rapid-cycle reductions in alert burden that were temporally associated with lower pharmacist override rates in a subgroup of DDIs not directly affected by the interventions; meanwhile, the pharmacists' frequency of selecting the 'cancel' option increased. We hypothesize that reducing the alert burden enabled pharmacists to devote more attention to clinically relevant alerts.

Observasjonsstudier

Andersson ML, Bottiger Y, Lindh JD, Wettermark B, Eiermann B. **Impact of the drug-drug interaction database SFINX on prevalence of potentially serious drug-drug interactions in primary health care**. Eur J Clin Pharmacol 2013;69(3):565-571.

Abstract: PURPOSE: To investigate the impact of the integration of the drug-drug interaction database SFINX into primary health care records on the prevalence of potentially serious drug-drug interactions., METHODS: The study was a controlled before-and-after study on the prevalence of potential drug-drug interactions before and after the implementation of SFINX at 15 primary healthcare centres compared with 5 centres not receiving the intervention. Data on dispensed prescriptions from health care centres were retrieved from the Swedish prescribed drug register and analysed for September-December 2006 (pre-intervention) and September-December 2007 (post-intervention). All drugs dispensed during each 4 month period were regarded as potentially interacting., RESULTS: Use of SFINX was associated with a 17% decrease, to 1.81 x 10(-3) from 2.15 x 10(-3) interactions per prescribed drug-drug pair, in the prevalence of potentially serious drug-drug interactions ($p = 0.042$), whereas no significant effect was observed in the control group. The change in prevalence of potentially serious drug-drug interactions did not differ significantly between the two study groups. The majority of drug-drug interactions identified were related to chelate formation., CONCLUSION: Prescriptions resulting in potentially serious drug-drug interactions were significantly reduced after integration of the drug-drug interaction database SFINX into electronic health records in primary care. Further studies are needed to demonstrate the effectiveness of drug-drug interaction warning systems.

Cote GA, Rice JP, Bulsiewicz W, Norvell JP, Christensen K, Bobb A, et al. **Use of physician education and computer alert to improve targeted use of gastroprotection among NSAID users**. The American journal of gastroenterology 2008;103(5):1097-1103.

Abstract: BACKGROUND: Gastrointestinal (GI) hemorrhage accounts for 200-400,000 admissions in the United States annually. Around 50% of patients with bleeding ulcer have used aspirin and/or nonsteroidal anti-inflammatory drugs (NSAIDs). Misoprostol and proton pump inhibitors (PPIs) may reduce NSAID-related upper GI tract complications in high-risk patients, but their targeted use may be suboptimal., AIM: To determine the impact of physician education, a computer alert, or both on the targeted use of GI prophylaxis in high-risk patients discharged from hospital., METHODS: To target high-risk patients, we studied cardiology telemetry and coronary care unit (CCU) services. Every 4th wk, 8 different residents managed these patients. Over a 32-wk period, residents were assigned to one of the four 8-wk groups sequentially: Group I: control; Group II: physician education, consisting of a 10-min tutorial on risk factors for NSAID-related GI complications; Group III: computer alert; and Group IV: combination of tutorial and computer alert. We reviewed all patients admitted to these cardiology services during the study period. Exclusion criteria included discharge on no ulcerogenic medications, incomplete discharge data, and inpatient death. Patients readmitted during the study period were not re-counted. Medical records were reviewed for discharge medications, past medical history, demographics, admission and discharge diagnoses, hospital days, and the Charlson comorbidity index. Other indications for acid suppression were documented. A chi(2) test was used to determine independence among all four groups., RESULTS: We enrolled 721 patients, of whom 120 (16.7%) were excluded. The remaining 601 were divided by physician intervention group and risk for NSAID-related GI complications. In total, 270 of 601 (45%) patients were discharged home on appropriate gastroprotection. The overall use of gastroprotection increased from 43 to 61% with the combination of an electronic alert and physician education ($P < 0.001$); among PPI-naive patients, the rate increased from 26% to 55% ($P < 0.0001$). When stratified by known risk factors for GI complications of NSAIDs, the odds of receiving a gastroprotective prescription among PPI-naive patients was 1.6 with education alone, 1.8 with electronic alert alone, and 2.9 with the combination ($P < 0.0001$)., CONCLUSION: The combination of a computer alert and brief physician education led to an increase in the use of gastroprotection among NSAID users at the time of discharge from hospital. This effect was most evident among high-risk, PPI-naive patients. Combining physician education and a computer alert appears to have an additive effect.

Judge J, Field TS, DeFlorio M, Laprino J, Auger J, Rochon P, et al. **Prescribers' responses to alerts during medication ordering in the long term care setting**. Journal of the American Medical Informatics Association : JAMIA 2006;13(4):385-390.

Abstract: OBJECTIVE: Computerized physician order entry with clinical decision support has been shown to improve medication safety in adult inpatients, but few data are available regarding its usefulness in the long-term care setting. The objective of this study was to examine opportunities for improving medication safety in that clinical setting by determining the proportion of medication orders that would generate a warning message to the prescriber via a computerized clinical decision support system and assessing the extent to which these alerts would affect prescribers' actions., DESIGN: The study was set within a randomized controlled trial of computerized clinical decision support conducted in the long-stay units of a large, academically-affiliated long-term care facility. In March 2002, a computer-based clinical decision support system (CDSS) was added to an existing computerized physician order entry (CPOE) system. Over a subsequent one-year study period, prescribers ordering drugs for residents on three resident-care units of the facility were presented with alerts; these alerts were not displayed to prescribers in the four control units., MEASUREMENTS: We assessed the frequency of drug orders associated with various categories of alerts across all participating units of the facility. To assess the impact of actually receiving an alert on prescriber behavior during drug ordering, we calculated separately for the intervention and control units the proportion of the alerts, within each category, that were followed by an appropriate action and estimated the relative risk of an appropriate action in the intervention units compared to the control units., RESULTS: During the 12 months of the study, there were 445 residents on the participating units of the facility, contributing 3,726 resident-months of observation time. During this period, 47,997 medication orders were entered through the CPOE system-approximately 9 medication orders per resident per month. 9,414

alerts were triggered (2.5 alerts per resident-month). The alert categories most often triggered were related to risks of central nervous system side-effects such as over-sedation (20%). Alerts for risk of drug-associated constipation (13%) or renal insufficiency/electrolyte imbalance (12%) were also common. Twelve percent of the alerts were related to orders for warfarin. Overall, prescribers who received alerts were only slightly more likely to take an appropriate action (relative risk 1.11, 95% confidence interval 1.00, 1.22). Alerts related to orders for warfarin or central nervous system side effects were most likely to engender an appropriate action, such as ordering a recommended laboratory test or canceling an ordered drug., CONCLUSION: Long-term care facilities must implement new system-level approaches with the potential to improve medication safety for their residents. The number of medication orders that triggered a warning message in this study suggests that CPOE with a clinical decision support system may represent one such tool. However, the relatively low rate of response to these alerts suggests that further refinements to such systems are required, and that their impact on medication errors and adverse drug events must be carefully assessed.

Malone DC, Saverno KR. **Evaluation of a wireless handheld medication management device in the prevention of drug-drug interactions in a Medicaid population**. Journal of managed care pharmacy : JMCP 2012;18(1):33-45.

Abstract: BACKGROUND: With the passage of the Health Information Technology for Economic and Clinical Health (HITECH) Act, widespread adoption of certain health information technologies, such as electronic health records (EHRs) and electronic prescribing (e-prescribing), is imminent. Drug-drug interaction (DDI) screening and medication history information are commonly incorporated into health information exchange systems to improve medical decision making, safety, and quality of care, but the value of these features is unclear., OBJECTIVE: To evaluate the effect of providing access to an early generation electronic medication management program with medication history accessible to prescribers via a wireless handheld personal digital assistant (PDA) device on the incidence of potential DDIs (i.e., DDIs that may or may not cause patient harm)., METHODS: This study employed a retrospective pre-intervention/post-intervention study design with a comparison group to evaluate the effectiveness of a wireless handheld medication management program in preventing serious potential DDIs. Licensed prescribers in a state Medicaid program who wrote prescriptions during the period from August 2003 through June 2006 were included in this study. The intervention (PDA) group consisted of clinicians who requested and were granted access to the wireless handheld device containing prescription drug history between August 1, 2004, and June 30, 2005. Initially the device contained 100-day patient-specific medication history, but other functionalities were added during the study period including the ability to check for drug-drug interactions and e-prescribing. The comparison group consisted of prescribers who sent a request to obtain, but did not receive, the wireless handheld device during the same time period. Baseline prescribing patterns of 25 previously identified clinically important potential DDIs were assessed over two 12-month periods, one period prior to (baseline) and one period after (follow-up) an index date (date of device deployment for PDA group; date of request for comparison group). A random-effects negative binomial model was used to analyze the primary outcome, the number of potential DDIs per prescriber per 12-month time period. A secondary outcome of interest, the likelihood that a prescriber would prescribe at least 1 potentially interacting medication pair during the baseline and follow-up periods, was analyzed using a random-effects logistic model., RESULTS: A total of 1,615 prescribers constituted the PDA group, and 600 prescribers made up the comparison group. Prescribers in the 2 groups were significantly different in their specialty practice areas (P less than 0.001), number of pharmacy claims at baseline (P less than 0.001), and the likelihood of prescribing at least 1 potential DDI combination during the 1-year baseline period (P=0.003). However, the prescriber groups were similar in their average age (P=0.241) and geographic location (P=0.181). The most widely prescribed potential DDIs included those involving warfarin with nonsteroidal anti-inflammatory drugs (NSAIDs) and thyroid hormones. The median number of patient medication history updates requested per PDA group prescriber during follow-up was 24 (range 0 to 1,073). At baseline, 1,104 (68.4%) of the PDA group and 449 (74.8%) of the comparison group had no potential DDIs. During the next year, 1,131 (70.0%) and 462 (77.0%) of the PDA group and comparison group, respectively, had no DDIs. The incidence rate ratio was 1.01 (95% CI=0.87-1.17) for the PDA group relative to the comparison group for change in number of potential DDIs. In the logistic regression model, the odds of prescribing at least 1 potential DDI did not significantly differ by

group (odds ratio=1.26, 95% CI=0.96-1.66). These results indicate that there was no significant difference between the intervention and comparison group with regard to the change in the rate of potential DDIs between the baseline and follow-up periods., CONCLUSION: A stand-alone medication management program in a wireless

Piontek F, Kohli R, Conlon P, Ellis JJ, Jablonski J, Kini N. **Effects of an adverse-drug-event alert system on cost and quality outcomes in community hospitals**. Am J Health Syst Pharm 2010;67(8):613-620.

Abstract: Purpose. The effects of an adverse-drugevent (ADE) alert system on cost and quality outcomes in community hospitals were evaluated. Methods. This retrospective observational study evaluated the effects of an ADE alert system in seven hospitals in the Trinity Health network. Outcomes for all inpatients admitted to these hospitals after and one year before the deployment of an ADE alert system were evaluated. Inpatients in two network hospitals that lacked any computerized ADE alert system constituted the external control group. Administrative data were gathered for patients from these facilities for the same time frames as for the preimplementation and postimplementation groups. Primary outcomes evaluated included pharmacy department costs, variable drug costs, and mortality rates. Secondary outcomes included total hospitalization costs, length of hospital stay (LOS), rate of readmission, and case-mix index. Mean differences in primary and secondary outcome measures across all four groups were examined using analysis of variance. Results. Significant decreases in mean pharmacy department costs per patient were observed from preimplementation to postimplementation ($p < 0.001$), while pharmacy department costs increased significantly in the external control group ($p = 0.029$). Drug costs decreased significantly from baseline ($p < 0.001$) in the postimplementation group. Drug costs increased significantly in the external control group ($p = 0.029$). Severity-adjusted mortality rates and LOS decreased significantly in the postimplementation group. Total patient hospitalization costs, both crude and severity adjusted, significantly increased in both groups. Conclusion. Implementation of an ADE alert system in seven community hospitals demonstrated significant decreases in pharmacy department costs, variable drug costs, and severity-adjusted mortality rates.

Sellier E, Colombet I, Sabatier B, Breton G, Nies J, Zapletal E, et al. **Effect of alerts for drug dosage adjustment in inpatients with renal insufficiency**. Journal of the American Medical Informatics Association : JAMIA 2009;16(2):203-210.

Abstract: OBJECTIVES: Medication errors constitute a major problem in all hospitals. Between 20% and 46% of prescriptions requiring dosage adjustments based on renal function are inappropriate. This study aimed to determine whether implementing alerts at the time of ordering medication integrated into the computerized physician order entry decreases the proportion of inappropriate prescriptions based on the renal function of inpatients., DESIGN: Six alternating 2-month control and intervention periods were conducted between August 2006 and August 2007 in two medical departments of a teaching hospital in France. A total of 603 patients and 38 physicians were included. During the intervention periods, alerts were triggered if a patient with renal impairment was prescribed one of the 24 targeted drugs that required adjustment according to estimated glomerular filtration rate (eGFR)., MEASUREMENTS: The main outcome measure was the proportion of inappropriate first prescriptions, according to recommendation., RESULTS: A total of 1,122 alerts were triggered. The rate of inappropriate first prescriptions did not differ significantly between intervention and control periods (19.9% vs. 21.3%; p=0.63). The effect of intervention differed significantly between residents and senior physicians (p=0.03). Residents tended to make fewer errors in intervention versus control periods (Odds ratio 0.69; 95% confidence interval 0.41 to 1.15), whereas senior physicians tended to make more inappropriate prescriptions in intervention periods (odds ratio 1.88; 95% confidence interval 0.91 to 3.89)., CONCLUSION: Alert activation was not followed by a significant decrease in inappropriate prescriptions in our study. Thus, it is still necessary to evaluate the impact of these systems if newly implemented in other settings thanks to studies also designed to watch for possible unanticipated effects of decision supports and their underlying causes.

Automated dispensing systems & Barcode

RCT

Merry AF, Webster CS, Hannam J, Mitchell SJ, Henderson R, Reid P, et al. **Multimodal system designed to reduce errors in recording and administration of drugs in anaesthesia: Prospective randomised clinical evaluation**. BMJ (Online) 2011;343(7826).

Abstract: Objective: To clinically evaluate a new patented multimodal system (SAFERSleep) designed to reduce errors in the recording and administration of drugs in anaesthesia. Design: Prospective randomised open label clinical trial. Setting: Five designated operating theatres in a major tertiary referral hospital. Participants: Eighty nine consenting anaesthetists managing 1075 cases in which there were 10 764 drug administrations. Intervention: Use of the new system (which includes customised drug trays and purpose designed drug trolley drawers to promote a well organised anaesthetic workspace and aseptic technique; pre-filled syringes for commonly used anaesthetic drugs; large legible colour coded drug labels; a barcode reader linked to a computer, speakers, and touch screen to provide automatic auditory and visual verification of selected drugs immediately before each administration; automatic compilation of an anaesthetic record; an on-screen and audible warning if an antibiotic has not been administered within 15 minutes of the start of anaesthesia; and certain procedural rules-notably, scanning the label before each drug administration) versus conventional practice in drug administration with a manually compiled anaesthetic record. Main outcome measures: Primary: composite of errors in the recording and administration of intravenous drugs detected by direct observation and by detailed reconciliation of the contents of used drug vials against recorded administrations; and lapses in responding to an intermittent visual stimulus (vigilance latency task). Secondary: outcomes in patients; analyses of anaesthetists' tasks and assessments of workload; evaluation of the legibility of anaesthetic records; evaluation of compliance with the procedural rules of the new system; and questionnaire based ratings of the respective systems by participants. Results: The overall mean rate of drug errors per 100 administrations was 9.1 (95% confidence interval 6.9 to 11.4) with the new system (one in 11 administrations) and 11.6 (9.3 to 13.9) with conventional methods (one in nine administrations) (P=0.045 for difference). Most were recording errors, and, though fewer drug administration errors occurred with the new system, the comparison with conventional methods did not reach significance. Rates of errors in drug administration were lower when anaesthetists consistently applied two key principles of the new system (scanning the drug barcode before administering each drug and keeping the voice prompt active) than when they did not: mean 6.0 (3.1 to 8.8) errors per 100 administrations v 9.7 (8.4 to 11.1) respectively (P=0.004). Lapses in the vigilance latency task occurred in 12% (58/471) of cases with the new system and 9% (40/473) with conventional methods (P=0.052). The records generated by the new system were more legible, and anaesthetists preferred the new system, particularly in relation to long, complex, and emergency cases. There were no differences between new and conventional systems in respect of outcomes in patients or anaesthetists' workload. Conclusions The new system was associated with a reduction in errors in the recording and administration of drugs in anaesthesia, attributable mainly to a reduction in recording errors. Automatic compilation of the anaesthetic record increased legibility but also increased lapses in a vigilance latency task and decreased time spent watching monitors. Trial registration: Australian New Zealand Clinical Trials Registry No 12608000068369.

Observasjonsstudier

Chapuis C, Roustit M, Bal G, Schwebel C, Pansu P, David-Tchouda S, et al. **Automated drug dispensing system reduces medication errors in an intensive care setting**. Crit Care Med 2010;38(12):2275-2281.

Abstract: OBJECTIVES: We aimed to assess the impact of an automated dispensing system on the incidence of medication errors related to picking, preparation, and administration of drugs in a medical intensive care unit. We also evaluated the clinical significance of such errors and user satisfaction., DESIGN: Preintervention and postintervention study involving a control and an intervention medical intensive care unit., SETTING: Two medical intensive care units in the same department of a 2,000-bed university hospital., PATIENTS: Adult medical intensive care patients., INTERVENTIONS: After a 2-month observation period, we implemented an automated dispensing system in one of the units (study unit) chosen randomly, with the other unit being the control., MEASUREMENTS AND MAIN RESULTS: The overall error rate was expressed as a percentage of total opportunities for error.

The severity of errors was classified according to National Coordinating Council for Medication Error Reporting and Prevention categories by an expert committee. User satisfaction was assessed through self-administered questionnaires completed by nurses. A total of 1,476 medications for 115 patients were observed. After automated dispensing system implementation, we observed a reduced percentage of total opportunities for error in the study compared to the control unit (13.5% and 18.6%, respectively; p<.05); however, no significant difference was observed before automated dispensing system implementation (20.4% and 19.3%, respectively; not significant). Before-and-after comparisons in the study unit also showed a significantly reduced percentage of total opportunities for error (20.4% and 13.5%; p<.01). An analysis of detailed opportunities for error showed a significant impact of the automated dispensing system in reducing preparation errors (p<.05). Most errors caused no harm (National Coordinating Council for Medication Error Reporting and Prevention category C). The automated dispensing system did not reduce errors causing harm. Finally, the mean for working conditions improved from 1.0+/-0.8 to 2.5+/-0.8 on the four-point Likert scale., CONCLUSIONS: The implementation of an automated dispensing system reduced overall medication errors related to picking, preparation, and administration of drugs in the intensive care unit. Furthermore, most nurses favored the new drug dispensation organization.

Cochran GL, Haynatzki G. **Comparison of medication safety effectiveness among nine critical access hospitals**. American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists 2013;70(24):2218-2224.

Abstract: PURPOSE: The rates of medication errors across three different medication dispensing and administration systems frequently used in critical access hospitals (CAHs) were analyzed., METHODS: Nine CAHs agreed to participate in this prospective study and were assigned to one of three groups based on similarities in their medication-use processes: (1) less than 10 hours per week of onsite pharmacy support and no bedside barcode system, (2) onsite pharmacy support for 40 hours per week and no bedside barcode system, and (3) onsite pharmacy support for 40 or more hours per week with a bedside barcode system. Errors were characterized by severity, phase of origination, type, and cause. Characteristics of the medication being administered and a number of best practices were collected for each medication pass. Logistic regression was used to identify significant predictors of errors., RESULTS: A total of 3103 medication passes were observed. More medication errors originated in hospitals that had onsite pharmacy support for less than 10 hours per week and no bedside barcode system than in other types of hospitals. A bedside barcode system had the greatest impact on lowering the odds of an error reaching the patient. Wrong dose and omission were common error types. Human factors and communication were the two most frequently identified causes of error for all three systems., CONCLUSION: Medication error rates were lower in CAHs with 40 or more hours per week of onsite pharmacy support with or without a bedside barcode system compared with hospitals with less than 10 hours per week of pharmacy support and no bedside barcode system.

Dwibedi N, Sansgiry SS, Frost CP, Dasgupta A, Jacob SM, Tipton JA, et al. **Effect of bar-code-assisted medication administration on nurses' activities in an intensive care unit: a time-motion study**. American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists 2011;68(11):1026-1031.

Abstract: PURPOSE: The effect of bar-code-assisted medication administration (BCMA) on nurses' activities in an intensive care unit was evaluated., METHODS: A prospective, observational, time-motion study was conducted by considering two approaches to medication administration in an intensive care unit: paper-based medication administration (PBMA) and BCMA. The time spent on nursing activities was measured using a prevalidated time-motion observation instrument and categorized based on workflow factors such as direct patient care, indirect patient care, administration, and miscellaneous or other. A descriptive analysis was conducted with the amount of time spent on each of the nursing activities. A multivariate analysis of covariance was conducted to assess the difference between the two approaches for the amount of time spent on various categorized nursing activities. Covariates included in the analysis were patient characteristics, medication administration characteristics, and number of nurses involved in medication administration., RESULTS: A total of 101 PBMAs and 151 BCMAs were reviewed. The mean duration of total medication administration time was higher in the BCMA phase compared with the PBMA phase, as was the mean time spent on direct patient care activity. However, nurses spent less time on ad-

ministration activity during BCMA. Statistical analysis revealed that the medication administration approach (BCMA versus PBMA) had a significant effect on time spent on direct patient care and medication administration activities., CONCLUSION: The implementation of BCMA led to a reduction in the time spent by nurses on medication administration activities and increased the time spent on direct patient care activities.

Evley R, Russell J, Mathew D, Hall R, Gemmell L, Mahajan RP. **Confirming the drugs administered during anaesthesia: a feasibility study in the pilot National Health Service sites, UK**. Br J Anaesth 2010;105(3):289-296.

Abstract: BACKGROUND: To help prevent drug errors, it is recommended that drugs should be confirmed/checked with a second person before administration. We aimed to assess the feasibility of introducing second-person or electronic bar-code confirmation of drugs, administered during anaesthesia, in the National Health Service (NHS) settings in the UK., METHODS: Seven NHS sites took part in a pilot study over a 3 month period. Five used a second-person and two used bar-code electronic confirmation of drugs given during anaesthesia. A total of 36 consultant anaesthetists and three trainees, 15 operating department practitioners (ODPs), and seven anaesthetic nurses participated. A group of anaesthetists, ODPs, and nurse practitioners (n=11) from different NHS sites independently observed both methodologies. In addition, each site was visited and observed by one of the study investigators. At the end of the study period, four focus groups (two with participants from pilot sites and two with observers) were held. The discussions were taped, transcribed, and qualitatively analysed. Data were triangulated using observer's notes and investigator's reflective diaries, and processed using line-by-line coding. The codes were then synthesized into themes., RESULTS: Both methods were perceived to contribute to the prevention of drug errors. For the two-person confirmation to be carried out correctly, there should be no distraction or time pressure. The main limitation to the feasibility was that the continuous presence of the second person was not always possible. The process also met with resistance from the staff at some pilot sites. Electronic confirmation was always feasible, as it did not require the presence of a second person. It was found to be intuitive to the anaesthetist's current working practice. However, there were some practical issues related to introduction of new technology and an initial learning curve., CONCLUSIONS: The introduction of two-person confirmation to the NHS would have a significant impact on the existing working practices. Issues related to resources and a cultural change will need to be addressed. Electronic confirmation was more feasible, but the technological aspects of its integration into the operating theatre environment, and learning, will require further attention.

Morriss FH, Jr., Abramowitz PW, Nelson SP, Milavetz G, Michael SL, Gordon SN. **Risk of adverse drug events in neonates treated with opioids and the effect of a bar-code-assisted medication administration system**. American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists 2011;68(1):57-62.

Abstract: PURPOSE: The risk of adverse drug events (ADEs) in neonates treated with opioids and the effect of a bar-code-assisted medication administration (BCMA) system were studied., METHODS: A prospective cohort study of neonates in a neonatal intensive care unit (NICU) was conducted. A BCMA system was operative for 50% of the study period. Structured medical record audits were conducted to identify medication errors and preventable ADEs. Stratified frequency distribution and Cox proportional hazards analyses were used., RESULTS: Of 618 patients, 78 (12.6%) received postoperative care, 280 (45.3%) required assisted ventilation, and 72 (11.7%) were treated with opioids during their hospitalization. A total of 32 first preventable ADEs occurred. Univariate analyses demonstrated that postoperative status, assisted ventilation, and opioid administration were each significantly associated with ADEs. However, stratified frequency distribution analyses indicated that opioid administration during hospitalization was associated with preventable ADEs, controlling for postoperative status ($p = 0.0019$) or assisted ventilation ($p = 0.0007$). The odds ratio for any preventable ADE occurrence in a patient treated with an opioid was 4.74 compared with an infant not treated with an opioid. Patients who were treated with an opioid in the absence of a BCMA system had a 10% probability of an ADE after hospitalization for six days., CONCLUSION: Infants in a NICU who were treated with opioids were at greater risk of a preventable ADE than other patients, adjusted for two medical conditions, assisted ventilation and postoperative status. A BCMA system reduced the risk of harm from an opioid medication error.

Seibert HH, Maddox RR, Flynn EA, Williams CK. **Effect of barcode technology with electronic medication administration record on medication accuracy rates**. American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists 2014;71(3):209-218.

Abstract: PURPOSE: The effect of barcode-assisted medication administration (BCMA) with electronic medication administration record (eMAR) technology on the occurrence of medication administration errors was evaluated., METHODS: A pretest-posttest nonequivalent comparison group was used to investigate the effect of BCMA-eMAR on the medication administration accuracy rates at two community-based hospitals. Patient care units included three matched pairs in the two hospitals-two medical-surgical, two telemetry, and two rehabilitation units-plus a medical-surgical intensive care unit, an emergency department, and both an inpatient oncology unit and an outpatient oncology service at one of the hospitals. Medication administration accuracy rates were observed and recorded before (phase 1) and approximately 6 and 12 months after (phases 2 and 3, respectively) the implementation of BCMA-eMAR., RESULTS: The overall accuracy rate at hospital 1 increased significantly from phase 1 (89%) to phase 3 (90%) ($p = 0.0015$); if wrong-time errors are excluded, the accuracy rate improved from 92% in phase 1 to 96% in phase 3 ($p = 0.000008$). The overall accuracy rate did not change significantly from phase 1 to phase 3 at hospital 2; when wrong-time errors were excluded from consideration, the accuracy rate improved from 93% in phase 1 to 96% in phase 3 ($p = 0.015$)., CONCLUSION: Implementation of BCMA-eMAR in two hospitals was associated with significant increases in total medication accuracy rates in most study units and did not introduce new types of error into the medication administration process. Accuracy rates further improved when wrong-time errors were excluded from analysis. The frequency of errors preventable by BCMA-eMAR decreased significantly in both hospitals after implementation of that technology. BCMA-eMAR and direct observation were more effective than voluntary reporting programs at intercepting and recording errors and preventing them from reaching patients.

Westbrook JI, Li L, Georgiou A, Paoloni R, Cullen J. **Impact of an electronic medication management system on hospital doctors' and nurses' work: a controlled pre-post, time and motion study**. Journal of the American Medical Informatics Association : JAMIA 2013;20(6):1150-1158.

Abstract: OBJECTIVE: To quantify and compare the time doctors and nurses spent on direct patient care, medication-related tasks, and interactions before and after electronic medication management system (eMMS) introduction., METHODS: Controlled pre-post, time and motion study of 129 doctors and nurses for 633.2 h on four wards in a 400-bed hospital in Sydney, Australia. We measured changes in proportions of time on tasks and interactions by period, intervention/control group, and profession., RESULTS: eMMS was associated with no significant change in proportions of time spent on direct care or medication-related tasks relative to control wards. In the post-period control ward, doctors spent 19.7% (2 h/10 h shift) of their time on direct care and 7.4% (44.4 min/10 h shift) on medication tasks, compared to intervention ward doctors (25.7% (2.6 h/shift; $p=0.08$) and 8.5% (51 min/shift; $p=0.40$), respectively). Control ward nurses in the post-period spent 22.1% (1.9 h/8.5 h shift) of their time on direct care and 23.7% on medication tasks compared to intervention ward nurses (26.1% (2.2 h/shift; $p=0.23$) and 22.6% (1.9 h/shift; $p=0.28$), respectively). We found intervention ward doctors spent less time alone ($p=0.0003$) and more time with other doctors ($p=0.003$) and patients ($p=0.009$). Nurses on the intervention wards spent less time with doctors following eMMS introduction ($p=0.0001$)., CONCLUSIONS: eMMS introduction did not result in redistribution of time away from direct care or towards medication tasks. Work patterns observed on these intervention wards were associated with previously reported significant reductions in prescribing error rates relative to the control wards.

Samstemming (medication reconsiliation)

RCT

Schnipper JL, Gandhi TK, Wald JS, Grant RW, Poon EG, Volk LA, et al. **Effects of an online personal health record on medication accuracy and safety: a cluster-randomized trial**. Journal of the American Medical Informatics Association : JAMIA 2012;19(5):728-734.

Abstract: OBJECTIVE: To determine the effects of a personal health record (PHR)-linked medications module on medication accuracy and safety., DESIGN: From September

2005 to March 2007, we conducted an on-treatment sub-study within a cluster-randomized trial involving 11 primary care practices that used the same PHR. Intervention practices received access to a medications module prompting patients to review their documented medications and identify discrepancies, generating 'eJournals' that enabled rapid updating of medication lists during subsequent clinical visits., MEASUREMENTS: A sample of 267 patients who submitted medications eJournals was contacted by phone 3 weeks after an eligible visit and compared with a matched sample of 274 patients in control practices that received a different PHR-linked intervention. Two blinded physician adjudicators determined unexplained discrepancies between documented and patient-reported medication regimens. The primary outcome was proportion of medications per patient with unexplained discrepancies., RESULTS: Among 121,046 patients in eligible practices, 3979 participated in the main trial and 541 participated in the sub-study. The proportion of medications per patient with unexplained discrepancies was 42% in the intervention arm and 51% in the control arm (adjusted OR 0.71, 95% CI 0.54 to 0.94, p=0.01). The number of unexplained discrepancies per patient with potential for severe harm was 0.03 in the intervention arm and 0.08 in the control arm (adjusted RR 0.31, 95% CI 0.10 to 0.92, p=0.04)., CONCLUSIONS: When used, concordance between documented and patient-reported medication regimens and reduction in potentially harmful medication discrepancies can be improved with a PHR medication review tool linked to the provider's medical record., TRIAL REGISTRATION NUMBER: This study was registered at ClinicalTrials.gov (NCT00251875).

Schnipper JL, Hamann C, Ndumele CD, Liang CL, Carty MG, Karson AS, et al. **Effect of an electronic medication reconciliation application and process redesign on potential adverse drug events: a cluster-randomized trial**. Arch Intern Med 2009;169(8):771-780.

Abstract: BACKGROUND: Medication reconciliation at transitions in care is a national patient safety goal, but its effects on important patient outcomes require further evaluation. We sought to measure the impact of an information technology-based medication reconciliation intervention on medication discrepancies with potential for harm (potential adverse drug events [PADEs])., METHODS: We performed a controlled trial, randomized by medical team, on general medical inpatient units at 2 academic hospitals from May to June 2006. We enrolled 322 patients admitted to 14 medical teams, for whom a medication history could be obtained before discharge. The intervention was a computerized medication reconciliation tool and process redesign involving physicians, nurses, and pharmacists. The main outcome was unintentional discrepancies between preadmission medications and admission or discharge medications that had potential for harm (PADEs)., RESULTS: Among 160 control patients, there were 230 PADEs (1.44 per patient), while among 162 intervention patients there were 170 PADEs (1.05 per patient) (adjusted relative risk [ARR], 0.72; 95% confidence interval [CI], 0.52-0.99). A significant benefit was found at hospital 1 (ARR, 0.60; 95% CI, 0.38-0.97) but not at hospital 2 (ARR, 0.87; 95% CI, 0.57-1.32) (P = .32 for test of effect modification). Hospitals differed in the extent of integration of the medication reconciliation tool into computerized provider order entry applications at discharge., CONCLUSIONS: A computerized medication reconciliation tool and process redesign were associated with a decrease in unintentional medication discrepancies with potential for patient harm. Software integration issues are likely important for successful implementation of computerized medication reconciliation tools.

Observasjonsstudier

Lee J, Leblanc K, Fernandes O, Huh JH, Wong G, Hamandi B, et al. **Medication reconciliation during internal hospital transfer and impact of computerized prescriber order entry**. Can J Hosp Pharm 2011;64 (1):85.

Abstract: Rationale: Internal hospital transfer is a vulnerable moment where patients are at high risk of medication discrepancies that can result in clinically significant harm, medication errors and adverse drug events. Methods: All patients transferred between 10 inpatient units at two tertiary care hospitals were prospectively assessed to identify discrepancies. Interfaces included transfers between: (1) units that both used Paper-based medication ordering systems; (2) units that both used CPOE-based systems; and (3) Paper-based and CPOE-based units ('Hybrid' transfer). The primary endpoint was the number of patients with at least one unintentional medication discrepancy during internal hospital transfer. Discrepancies were identified through assessment and comparison of a best possible medication transfer list with the actual transfer orders. Secondary objectives were to characterize and assess the potential clinical impact and severity of unintentional discrepancies, determine the

time required for transfer reconciliation and to investigate the influence of CPOE on the frequency of discrepancies. Results: Overall, 190 patients were screened and 129 patients were included. Eighty patients (62.0%) had at least one unintentional medication discrepancy at the time of transfer and the most common discrepancy was medication omission (55.6%). Forty-seven patients (36.4%) had at least one unintentional discrepancy with the potential to cause discomfort and/or clinical deterioration. The risk of discrepancies was present regardless of the medication-ordering system (Paper, CPOE or Hybrid). Conclusion: Clinically significant medication discrepancies occur commonly during internal hospital transfer. A structured, collaborative and clearly defined medication reconciliation process is needed to allow clinicians to effectively prevent internal transfer discrepancies and patient harm.

Lukket legemiddelsløyfe (closed loop for anaestesia)

RCT

Biswas I, Mathew PJ, Singh RS, Puri GD. **Evaluation of closed-loop anesthesia delivery for propofol anesthesia in pediatric cardiac surgery**. Paediatr Anaesth2013. p. 1145-1152.

Abstract: Objective The objective of this study was to compare the feasibility of closed-loop anesthesia delivery with manual control of propofol in pediatric patients during cardiac surgery. Methods Forty ASA II-III children, undergoing elective cardiac surgery under cardiopulmonary bypass (CPB) in a tertiary care hospital, were randomized to receive propofol either through a closed-loop anesthesia delivery system (CL group) or through traditional manual control (manual group) to achieve a target BIS of 50. Patients were induced and subsequently maintained with a propofol infusion. The propofol usage and the efficacy of closed-loop system in controlling BIS within +10 of the target were compared with that of manual control. Results The maintenance of BIS within +10 of target and intraoperative hemodynamic stability were similar between the two groups. However, induction dose of propofol was less in the CL group (2.06 + 0.79 mgkg⁻¹) than the manual group (2.95 + 1.03 mgkg⁻¹) (P = 0.006) with less overshoot of BIS during induction in the closed-loop group (P = 0.007). Total propofol used in the off-CPB period was less in the CL group (6.29 + 2.48 mgkg⁻¹ h⁻¹ vs 7.82 + 2.1 mgkg ⁻¹ h⁻¹) (P = 0.037). Phenylephrine use in the pre-CPB period was more in the manual group (16.92 + 10.92 mugkg ⁻¹ vs 5.79 + 5.98 mugkg⁻¹) (P = 0.014). Manual group required a median of 18 (range 8-29) dose adjustments per hour, while the CL group required none. Conclusion This study demonstrated the feasibility of closed-loop controlled propofol anesthesia in children, even in challenging procedures such as cardiac surgery. Closed-loop system needs further and larger evaluation to establish its safety and efficacy. 2013 John Wiley & Sons Ltd.

Hemmerling TM, Arbeid E, Wehbe M, Cyr S, Taddei R, Zaouter C. **Evaluation of a novel closed-loop total intravenous anaesthesia drug delivery system: a randomized controlled trial**. Br J Anaesth 2013;110(6):1031-1039.

Abstract: BACKGROUND: We have developed an automatic anaesthesia system for closed-loop administration of anaesthesia drugs. The control variables used were bispectral index (BIS) and Analgoscore for hypnosis and antinociception, respectively., METHODS: One hundred and eighty-six patients were randomly enrolled in two groups. Propofol, remifentanil, and rocuronium were administered using closed-loop feedback control (closed-loop, n = 93) or manually (control group, n = 93). The clinical performance of hypnosis control was determined by calculating the offset from a BIS of 45: 'excellent', 'good', 'poor', and 'inadequate' control was defined as BIS values within 10%, from 11% to 20%, from 21% to 30%, or >30% offset from the target. The clinical performance of analgesia was defined as the offset from Analgoscore values. Data presented as mean (standard deviation) (95% confidence interval)., RESULTS: Excellent or good control of hypnosis was achieved significantly longer in the closed-loop group [47.0 (9.8%) (45.0/49.0), 34.4 (4.7%) (33.5/35.4)] than in the control group [37.3 (14.3%) (34.4/40.2) and 32.3 (7.6%) (30.7/33.7)], respectively (P<0.0001 and 0.0085). Poor and inadequate control of hypnosis was significantly shorter in the closed-loop group [10.8 (5.0%) (9.8/11.8) and 7.7 (6.2%) (6.4/9.0)] than in the control group [14.7 (6.8%) (13.3/16.0) and 15.8 (14.7%) (12.8/18.8)], respectively (P<0.0001). Excellent control of analgesia was achieved significantly longer in the closed-loop group [78.7 (16.2%) (75.4/82.0)] than in the control group [73.7 (17.8%) (70.1/77.3)] (P=0.0456)., CONCLUSIONS: The closed-loop system was better at maintaining BIS and Analgoscore than manual administration.