

**Supplementary.** Materials, study design, outcome measures and results of 67 medication-related evaluation studies on CPOE.

Level	Source	Materials	Study design	Outcome measures	Results
I	Tierney et al. <sup>71</sup> 1993	Urban public hospital Internal medicine ward 68 teams 5219 patients	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• RCT</li> <li>• 17 months</li> <li>• Time-motion and chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Hospital cost (C)</li> <li>• LOS (C)</li> <li>• Time for ordering (T)</li> </ul>	<ul style="list-style-type: none"> <li>• A 12.% (\$887) reduction in charges (\$6964 vs \$6077, p=0.02). Significant reductions were demonstrated separately for bed charges, diagnostic test charges, and drug charges (p&lt;0.05).</li> <li>• The mean length of stay was 0.89 day shorter for the intervention group (p=.11).</li> <li>• For writing orders, interns in the intervention group spent an average of 5.5 minutes per patient more than in the control group (p&lt;0.0001).</li> </ul>
	Overhage et al. <sup>20</sup> 1996	1 institution with 6 medical services 78 physicians 1622 physician- patient contacts	<ul style="list-style-type: none"> <li>• Prospective, RCT</li> <li>• 6 months</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• % overall clinician compliance with preventive care recommendations (A)</li> </ul>	<ul style="list-style-type: none"> <li>• Differences were not considered significant between intervention and control physicians in term of compliance with preventive care guidelines at either the aggregate level (23% vs. 24%, p=0.78) or individual preventive care.</li> </ul>
	Overhage et al. <sup>25</sup> 1997	Teaching hospital General medicine ward 89 physicians 1686 patients 76 drug and 11 test orders	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• RCT</li> <li>• 30 weeks</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Rate of compliance in trigger and corollary orders (A)</li> <li>• # of intervention by pharmacist (AI)</li> <li>• LOS (C)</li> <li>• Hospital cost (C)</li> </ul>	<ul style="list-style-type: none"> <li>• A 25% (21.9% vs 46.3%) improvement in the ordering of corollary medications by faculty and residents was observed (P&lt;0.0001).</li> <li>• There were one-third fewer interventions initiated by pharmacists with intervention physicians compared to the control group (p=0.003)</li> <li>• No difference in LOS (95% CI -0.17 to 1.19; p=0.94).</li> <li>• No difference in hospital cost (95% CI \$828.41 to \$1316.85; p=0.68).</li> </ul>
	Shojania et al. <sup>26</sup> 1998	Tertiary care hospital 396 patients 1798 patients Vancomycin	<ul style="list-style-type: none"> <li>• Prospective, RCT and non-random controlled trial (before-after)</li> <li>• 9 months</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Frequency of initiation and renewal (A)</li> <li>• Duration of therapy (A)</li> <li>• Amount of drugs (C)</li> <li>• Cost of medication (C)</li> </ul>	<ul style="list-style-type: none"> <li>• 32% fewer orders (p&lt;0.04) and 28% fewer patients with Vancomycin initiating or renewing orders (p=0.02).</li> <li>• 36% reduction in duration of therapy (p=0.05).</li> <li>• The overall use of intravenous Vancomycin decreased (p&lt;0.01).</li> <li>• \$22,500 savings per year because of decreased Vancomycin use.</li> </ul>
	Dexter et al. <sup>31</sup> 2001	Teaching hospital General medicine service 202 physicians 6731 patients	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• RCT</li> <li>• 18 months</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Rates of use of preventive care (A)</li> </ul>	<ul style="list-style-type: none"> <li>• For patients with at least one indication, computerized reminders increased ordering rates for pneumococcal and influenza vaccine, prophylactic heparin, and aspirin at discharge (p&lt;0.001).</li> </ul>

	Dexter <i>et al.</i> <sup>40</sup> 2004	6 wards of a teaching hospital 3777 general medicine patients Influenza and Pneumococcal vaccines	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• RCT</li> <li>• 14 months</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Adherence to guideline(A)</li> </ul>	<ul style="list-style-type: none"> <li>• Patients with standing orders received an influenza vaccine more often (42%) than those patients with reminders (30%) during the order entry (p&lt;0.001). Patients with standing orders received a pneumococcal vaccine more often (51%) than those patients with reminders (31%) during the order entry (p&lt;0.001). Computer identified 50% and 22% of hospitalized patients as eligible for influenza and pneumococcal vaccinations, respectively, while 19% and 7% of these eligible patients already have been vaccinated (data from outside facilities were not present in evaluated system)</li> </ul>
	Rosenbloom <i>et al.</i> <sup>73</sup> 2005	Teaching hospital 147 clinicians 263100 order entry sessions 11879 pharmacy warning	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• RCT</li> <li>• 12 months</li> </ul>	<ul style="list-style-type: none"> <li>• Clinicians' access and utilization rates (C)</li> </ul>	<ul style="list-style-type: none"> <li>• In the intervention group ,the decision support features were controlled at least once on 3.8% of subject-days logged on (278 response); in the control group, it was accessed at least once on 0.6% of subject-days (18 response), with a response rate ratio adjusted for decision support frequency of 9.17 (p&lt;0.0005).</li> </ul>
	Judge <i>et al.</i> <sup>35</sup> 2006	Academic long-term care facility 445 residents 47997 orders 9414 alerts	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• RCT</li> <li>• 12 months</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Adherence (A)</li> </ul>	<ul style="list-style-type: none"> <li>• 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 cancelling an ordered drug.</li> </ul>
<b>II</b>	Kawahara & Jordan <sup>24</sup> 1989	Tertiary care hospital 229 Patients >69years with pneumonia, Cefonicide and cefuroxime	<ul style="list-style-type: none"> <li>• Retrospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• 2 years</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Guideline adherence (A)</li> <li>• Cost (C)</li> </ul>	<ul style="list-style-type: none"> <li>• The percentage of patients who were prescribed Cefuroxime decreased from 100% to 22%, while the percentage of patients receiving Cefonicid increased from 0% to 78%.</li> <li>• The average acquisition cost of two antibiotics per patient decreased from \$123 to \$48.</li> </ul>
	Bates <i>et al.</i> <sup>77</sup> 1994	Tertiary care hospital	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• time-motion</li> </ul>	<ul style="list-style-type: none"> <li>• Time to write orders on the computer (T)</li> </ul>	<ul style="list-style-type: none"> <li>• CPOE doubled the time required to write medication orders(p&lt;0.001)</li> </ul>

Bates et al. <sup>50</sup> 1998	Tertiary care hospital 2 ICU(1 surgical and 1 medical)+ 4 general care (2 surgical and 2 medical) 6711 patients	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• 15 month (6+9)</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Non-intercepted serious medication errors (Preventable ADEs, Non-intercepted potential ADEs, Non-preventable ADEs, Intercepted potential ADEs) (S)</li> </ul>	<ul style="list-style-type: none"> <li>• There was 55% decrease in non-intercepted serious medication errors (p=0.37) and 17% decrease in preventable ADEs (p=0.37).</li> </ul>
Evans et al. <sup>51</sup> 1998	Teaching hospital ICU 1681 patients	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• 3 years (1+2)</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• ADEs (S)</li> <li>• DDD (C)</li> <li>• Medication cost (C)</li> <li>• # of days of excessive antibiotics dosage (S)</li> <li>• LOS (C)</li> </ul>	<ul style="list-style-type: none"> <li>• ADEs due to anti-infective agents decreased from 28 during the pre-intervention period to 4 during the intervention period (p=0.018).</li> <li>• During the intervention period, patients received an average of 4.7 fewer doses of anti-infective agents (p =0.042),.</li> <li>• Average decrease of \$81 in the cost of anti-infective agents (p=0.079).</li> <li>• Average decrease of 2.9 days for excessive anti-infective dosages (p&lt; 0.001).</li> <li>• Significant decrease of LOS (p&lt;0.001).</li> </ul>
Bates et al. <sup>52</sup> 1999	Tertiary care hospital 3 medical units (2 general wards+ 1ICU)	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Non random controlled ( 7-10 weeks time series in 4 different years)</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Medication errors (exclude missed dose errors) (S)</li> <li>• ADE (S)</li> </ul>	<ul style="list-style-type: none"> <li>• The rate of all medication errors decreased by 83%; The non-missed dose medication-error rate fell 81% (p&lt;0.0001); Non-intercepted serious medication errors fell 86% (p&lt;0.0003).</li> <li>• The total ADE rate fell from 14.7 of 1,000 patient days at baseline to 9.6 of 1,000 patient-days during the last period of the intervention (p&lt;0.09).</li> </ul>
Evans et al. <sup>53</sup> 1999	Teaching hospital 13384 patients Vancomycine, Gentamicine, Imipenem, Cefazoline, Cefuroxime	<ul style="list-style-type: none"> <li>• Retrospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• 3 years(1+2)</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Excessive dosage (S)</li> <li>• ADEs (S)</li> <li>• Cost (C)</li> <li>• Change in renal function (S)</li> </ul>	<ul style="list-style-type: none"> <li>• 6% (46% vs 50%) decrease in excessive dose (p&lt;0.001); An average decrease of 2.8 (2.9 vs 4.7) days for excessive anti-infective dosages (p&lt;0.001).</li> <li>• 0.6% (0.3% vs 0.9%) decrease in ADEs (p&lt;0.001).</li> <li>• The patients during the intervention period received fewer doses of antibiotics (10.9 vs 13.4; p&lt;0.001), at less cost (\$98 vs \$128; p&lt;0.004).</li> <li>• The patients identified as receiving excessive dosage had experienced a stronger decrease in renal function more than patients who were not identified as receiving excessive dosage (25% vs 12% during the pre-intervention period and 23% vs 16% during the intervention period; p&lt;0.001).</li> </ul>

Teich et al. <sup>22</sup> 2000	Tertiary care hospital 2078 orders	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• 3 years (1+2)</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Exceed dose (S)</li> <li>• Guideline adherence (Medication, Route, Dose and frequency) (A)</li> </ul>	<ul style="list-style-type: none"> <li>• The percentage of doses that exceeded the highest recommended dose decreased from 2.1% to 0.56% (p&lt;0.001).</li> <li>• The use of Nizatidine (recommended drug) increased from 15.6% of all histamine H2-blocker orders to 81.3% (p&lt;0.001). Appropriate use of Ondansetron increased from 6% to 75% (p&lt;0.001). The use of prophylactic subcutaneous heparin sodium increased from 24% to 47% (p&lt;0.001).</li> </ul>
Chertow et al. <sup>23</sup> 2001	Tertiary care hospital 17828 patients, ( 7490 patients with renal insufficiency with 97151 orders) 500 drugs selected for advices	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Non-random controlled trial (before-after) with cross over design</li> <li>• 8 months (4*2)</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Rate of appropriate prescription by dose and frequency (A)</li> <li>• LOS (C)</li> <li>• Hospital and pharmacy cost (C)</li> <li>• Change in renal function (S)</li> </ul>	<ul style="list-style-type: none"> <li>• 13% (67% vs 54%) decrease in inappropriate dose (p&lt;0.001) and 24% (59% vs 35%) decrease in inappropriate frequency (p&lt;0.001).</li> <li>• Mean(SD) length of stay reduced from 4.5(4.8) days in the control period to 4.3(4.5) days in the intervention period (p=0.009).</li> <li>• No significant differences in estimated hospital and pharmacy cost.</li> <li>• No significant differences in the proportion of patients who experienced a decline in renal function during hospitalization.</li> </ul>
Mullett et al. <sup>54</sup> 2001	Tertiary care hospital Pediatric intensive care unit, 1758 patients Anti-infective agents	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• 12 months (6+6),</li> <li>• Chart review and Questionnaire</li> </ul>	<ul style="list-style-type: none"> <li>• Rate of pharmacy interventions (A)</li> <li>• Rate of sub therapeutic patient days (C)</li> <li>• Rate of excessive-dose days (S)</li> <li>• # of order place per course (C)</li> <li>• Direct cost (C)</li> <li>• Type and number doses per patient (C)</li> <li>• ADEs (S)</li> <li>• Rate of antibiotic-bacterial susceptibility mismatches (S)</li> <li>• User satisfaction (SU)</li> </ul>	<ul style="list-style-type: none"> <li>• The rate of pharmacy intervention for erroneous drug doses declined by 59% (p&lt;0.01) and there was a 58% decrease in the rate of clinician requests for anti-infective dosing help (p&lt;0.05).</li> <li>• The rate of anti-infective sub-therapeutic patient days decreased by 36% (p&lt;0.001).</li> <li>• The rate of excessive-dose days declined by 28% (p&lt;0.001).</li> <li>• The number of orders placed per anti-infective course decreased by 11.5% (p&lt;0.01).</li> <li>• The robust estimate of the anti-infective cost per patient decreased by 9% (p&lt;0.05).</li> <li>• The type and number of anti-infective doses per patient remained similar.</li> <li>• The rate of ADEs and preventable ADEs remained similar.</li> <li>• The rate of antibiotic-bacterial susceptibility mismatches remained similar.</li> <li>• The surveyed clinicians reported that use of the program improved their anti-infective agent choices as well as their awareness of impairments in renal function, and reduced likelihood of ADEs.</li> </ul>
Shu et al. <sup>78</sup> 2001	Tertiary care hospital 72 medical interns 2682 observation	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• 5 months (3+2)</li> <li>• Time-motion</li> </ul>	<ul style="list-style-type: none"> <li>• Time for ordering (T)</li> </ul>	<ul style="list-style-type: none"> <li>• Interns spent 9.0% of their time ordering with CPOE, compared to 2.1% before CPOE usage. However CPOE saved them 2% of their other time, so that the net difference was 5% of their total time. This is counterbalanced by decreased time for other personnel such as nursing and pharmacy.</li> </ul>

Bizovi et al. <sup>60</sup> 2002	Tertiary care hospital Emergency unit, 14881 patients visit 3920 orders	<ul style="list-style-type: none"> <li>• Retrospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• 4 months (2+2)</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• # pharmacist clarification (AI)</li> <li>• % prescription errors (missing and incorrect information, missing dose, non-formulation medication, illegibility) (S)</li> </ul>	<ul style="list-style-type: none"> <li>• Percentage of pharmacist clarification decreased from 3.9% to 0.8 [OR=0.31 (95% CI=0.10 to 0.36)].</li> <li>• Percentage of errors decreased from 2.3% to 0.7% [OR=0.19 (95% CI=0.10 to 0.36)].</li> </ul>
Mekhjjan et al. <sup>61</sup> 2002	Tertiary care center with two hospitals <hr/> 116 orders (46+70) 31079 orders (1083+29996) <hr/> 28898 patients (14699+14099) <hr/> 1284 orders (888+396)	<ul style="list-style-type: none"> <li>• 10-12 months</li> <li>• Prospective, Non-random controlled trial (before-after)</li> <li>• Time and Motion and chart review</li> <li>• Retrospective</li> <li>• Non-random controlled trial (before-after)</li> </ul>	<ul style="list-style-type: none"> <li>• Medication turn-around time (T)</li> <li>• Improvement of countersignature</li> <li>• LOS (C)</li> <li>• Cost (C)</li> <li>• Physician and nurse transcription errors (S)</li> </ul>	<ul style="list-style-type: none"> <li>• Statically significant reductions were reported following the implementation of CPOE for medication turn-around times (64%, p&lt;0.001).</li> <li>• Countersignature by physician improved by 43% and 26% in OSUH and James.</li> <li>• Severity-adjusted length of stay decreased in OSUH (p=0.002), but not significantly James (p=0.356).</li> <li>• Although total cost per admission decreased significantly in some selected services, it did not change significantly across either institution.</li> <li>• CPOE combined with electronic medication administration record (eMAR) eliminated all physician and nursing transcription errors.</li> </ul>
Taylor et al. <sup>59</sup> 2002	Tertiary care hospital Acute care unit (2 years) Family medicine (two 10 days)	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• Time-motion and chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Medication errors (S)</li> <li>• Medication turn-around times (T)</li> <li>• Cost of process time (C)</li> </ul>	<ul style="list-style-type: none"> <li>• Prescribing errors were reduced by 50%.</li> <li>• The use of CPOE reduced the total time from writing the medication order to arrival of the medication from 245 min to 20 min, 92% increase in efficiency.</li> <li>• With reduction in total work time of pharmacists (200 min per day per person), clerks (120 min), and nurses (20 min), CPOE had the potential to save \$112 per day for each pharmacist, \$31 per day for each clerk, and \$14 per day for each nurse, and overall \$4,286,952 reduction in cost for the hospital per year.</li> </ul>
Fischer et al. <sup>27</sup> 2003	Tertiary care hospital 1045 orders Fluconazole, Levofloxacin, Metronidazole, Ranitidine, Amiodarone	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• 8 months (4+4)</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• DDD (C)</li> <li>• LOS (C)</li> <li>• Total drug expenditure (C)</li> <li>• % of conversion from intravenous to the oral or canceled the order (A)</li> </ul>	<ul style="list-style-type: none"> <li>• The average intravenous DDD declined by 11.1% (p=0.002), while average oral DDD increased by 3.7% (p=0.002).</li> <li>• Length of stay increased during the study period.</li> <li>• Total drug expenditure grew by 12.0%.</li> <li>• In 35.6% of orders for which a prompt was generated, the physician either made a conversion from the intravenous to the oral version or canceled the order altogether.</li> </ul>

<p>Igboechi <i>et al.</i><sup>55</sup> 2003</p>	<p><i>Tertiary care hospital</i></p>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Non-random controlled trial (before-after)</i></li> <li>• <i>3 years (2+1)</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Medication errors (S):</li> <li>• Incomplete orders</li> <li>• Incorrect orders</li> <li>• Illegible orders</li> <li>• Drug therapy problems</li> </ul>	<ul style="list-style-type: none"> <li>• Results indicated that in the first 12 months of CPOE, overall medication errors were reduced by more than 40%</li> <li>• Incomplete orders declined by more than 70% after CPOE introduction.</li> <li>• Incorrect orders decreased by at least 45% after CPOE introduction.</li> <li>• Illegal orders were virtually eliminated by CPOE introduction.</li> <li>• The level of medication errors categorized by drug therapy problems remained significantly unchanged.</li> </ul>
<p>King <i>et al.</i><sup>62</sup> 2003</p>	<p><i>Tertiary care hospital Pediatric Hospital(3 Medical unit and 2 surgical) 36103 patients</i></p>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Non-random controlled trial (before-after)</i></li> <li>• <i>5 years (3+2)</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Medication Errors Rate (MER) (S)</li> <li>• ADEs (S)</li> </ul>	<ul style="list-style-type: none"> <li>• After the introduction of the CPOE, the MERs was 40% lower in the intervention group compared to the control group (ratio=0.60; 95% CI 0.48-0.74).</li> <li>• No similar effect for ADEs was found (ratio of rate ratios = 1.30; 95% CI 0.47-3.52).</li> </ul>
<p>Bogucki <i>et al.</i><sup>28</sup> 2004</p>	<p><i>Tertiary care hospital Pediatric hospital 2124 order</i></p>	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Non-random controlled trial (before-after)</i></li> <li>• <i>2 months (1+1)</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Adherence to guideline (A)</li> <li>• Cost (C)</li> </ul>	<ul style="list-style-type: none"> <li>• The alert resulted in a 55% relative reduction in Methylprednisolone use (p&lt;0.0001) and an average reduction of more than three orders each day. Dexamethasone and Hydrocortisone, the recommended alternative medications, increase in use by 12% and 49% (p&lt;0.0001).</li> <li>• The alert resulted in an annual \$36552 cost reduction to the institution.</li> </ul>
<p>Cordero <i>et al.</i><sup>56</sup> 2004</p>	<p><i>Tertiary care hospital NICU 211 patients Caffeine and Gentamycine</i></p>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Non-random controlled trial (before-after)</i></li> <li>• <i>12 months (6+6)</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Medication errors (incorrect dose) (S)</li> <li>• Medication turn-around times (T)</li> </ul>	<ul style="list-style-type: none"> <li>• For Gentamycin dose adjustment in the pre-CPOE period, 5% over-dosages, 8% under-dosages, and 87% correct dosages were identified, and in the post-COPE period no medication errors occurred. At the time of suspected late-onset sepsis, Gentamycin dose was calculated incorrectly in two of 31 (6%) pre-CPOE infants and no such errors were noted in the post-CPOE period.</li> <li>• Mean(SD) turn-around time for the loading dose of caffeine reduced from 10.5(9.8) to 2.8(3.3) hour (p&lt;0.01). After CPOE implementation, the percentage of cases during each period where caffeine was administered before 2 and 3 hours increased from 10 to 35% and 12 to 63%.</li> </ul>

<p>Galanter <i>et al.</i><sup>30</sup> 2004</p>	<p><i>Tertiary care hospital</i> 620 patients <i>Digoxin</i></p>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Non-random controlled trial (before-after)</i></li> <li>• <i>12 months (6+6)</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• % of clinician response to the alerts (A)</li> </ul>	<ul style="list-style-type: none"> <li>• During CPOE, checking for serum values one hour after drug administration increased: 19% vs. 6% for Digoxin, 57% vs 9% for Potassium, and 40% vs 12% for Magnesium as well as 24 hours (p&lt;0.01). Electrolyte supplementation increased with newly reported hypokalemia and hypomagnesemia at one hour: 35% vs 6% and 49% vs 5% for potassium and magnesium, as well as at 24 hours (p&lt;0.01). During CPOE, supplementation for hypokalemia did not improve, whereas supplementation for hypomagnesemia improved at one hour (p&lt;0.05).</li> </ul>
<p>Hulgan <i>et al.</i><sup>29</sup> 2004</p>	<p><i>Tertiary care hospital (ICU+ general ward)</i> 15194 orders <i>Quinolones</i></p>	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Non-random controlled trial (before-after)</i></li> <li>• <i>105 weeks (54+51)</i></li> <li>• <i>Chart review</i></li> <li>• <i>Time-series analysis</i></li> </ul>	<ul style="list-style-type: none"> <li>• The proportion of Quinolone orders placed for oral formulations (A)</li> <li>• Reported reason for overriding the alerts (AI)</li> <li>• Direct cost (C)</li> </ul>	<ul style="list-style-type: none"> <li>• Orders for oral Quinolones increased from 4,202 (56%) before the intervention to 4,760 (62%) thereafter, without change in the total number of orders. In the time series analysis, there was an overall 5.6% increase (95% CI 2.8-8.4%; P&lt;0.001) in weekly oral Quinolone orders due to the intervention, with greatest effect on non-intensive care medical units.</li> <li>• The most common reason for overriding the CDSS recommendations was “Patient unable to take oral medications” (49%) and this was significantly more likely to be entered on a surgical unit (p=0.002).</li> <li>• Using the most conservative assumptions, that only one dose of i.v. Quinolone per order would be saved as a result of the intervention, and an acquisition cost difference between an i.v. and oral Quinolone dose is \$10, the intervention would save \$2,100-6,400 per year.</li> </ul>
<p>Krampera <i>et al.</i><sup>57</sup> 2004</p>	<p><i>Tertiary care hospital</i> <i>Bone marrow transplant unit</i> 41 patient 2264 prescriptions <i>Chemotherapy drugs</i></p>	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Non-random controlled trial (before-after)</i></li> <li>• <i>7 months</i></li> <li>• <i>Chart review and Questionnaire</i></li> </ul>	<ul style="list-style-type: none"> <li>• % of change in administered drugs based on system alerts (C)</li> <li>• ADEs related to drug interaction (S)</li> <li>• Administration errors (S)</li> <li>• Drug supply (C)</li> <li>• User satisfaction (SU)</li> </ul>	<ul style="list-style-type: none"> <li>• About 10% of the prescribed drugs were not eventually administered.</li> <li>• No unexpected drug-related complications were observed during the study. Before the introduction of the computerized system, the estimated incidence of ADEs was 10%.</li> <li>• After CPOE introduction no cases of wrong drug administration were mentioned whereas errors affected 5-10% of the prescription with the old system.</li> <li>• 20% decrease in the drug stock.</li> <li>• Most system users found a real improvement in drug management without increase of the process time.</li> </ul>

Potts <i>et al.</i> <sup>58</sup> 2004	<i>Tertiary care hospital Pediatric critical care unit 13828 orders 514 patients</i>	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Non-random controlled trial (before-after)</i></li> <li>• <i>4 months (2+2)</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Rate of potential ADEs (S)</li> <li>• Rate of Medication Prescribing errors (MPEs) (S)</li> <li>• Rate of rule violations (RVs) (S)</li> </ul>	<ul style="list-style-type: none"> <li>• 40.9% (2.2 vs 1.3) reduction in rate of potential ADEs per 100 orders (p=0.001).</li> <li>• 99.4% (30.1 vs 0.2) reduction in rate of MPEs per 100 orders (p=0.001).</li> <li>• 97.9% (6.8 vs 0.1) reduction in rate of RVs per 100 orders (p=0.001).</li> <li>• The overall error reduction was 95.9%</li> </ul>
Ali <i>et al.</i> <sup>32</sup> 2005	<i>Teaching ICU 91 patients</i>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Cohort(before-after)</i></li> <li>• <i>3 months (2+1)</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Orders for complex ICU care (A)</li> <li>• Use of higher-efficiency CPOE order paths (C)</li> </ul>	<ul style="list-style-type: none"> <li>• With the modified CPOE system, there was significant reduction in the adjusted number of orders for vasoactive infusions, sedative infusion, and ventilator management. There was also significant increase in the adjusted number of orders executed through ICU specific order sets after system modification.</li> </ul>
Galanter <i>et al.</i> <sup>63</sup> 2005	<i>Teaching hospital 323 alerts (after period) 87 alerts situations (before period) 233 patients</i>	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Non-random controlled trial (before-after)</i></li> <li>• <i>18 months (4+14)</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Contraindicated drug (S)</li> </ul>	<ul style="list-style-type: none"> <li>• The likelihood of a patient receiving at least one dose of contraindicated drug after the order was initiated decreased from 89% to 47% (p&lt;0.0001) after alert implementation. Analysis of the alerts seen by housestaff showed that alert compliance was higher in male patients (57% vs. 38%, p=0.02), increased with the duration of housestaff training, and increased in patient with more severe renal dysfunction.</li> </ul>
Han <i>et al.</i> <sup>69</sup> 2005	<i>Teaching pediatric hospital 1942 admissions</i>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Non-random controlled trial (before-after)</i></li> <li>• <i>18 months (13+5)</i></li> </ul>	<ul style="list-style-type: none"> <li>• Mortality rate (S)</li> </ul>	<ul style="list-style-type: none"> <li>• Univariate analysis revealed that mortality rate significantly increased from 2.80% (39 of 1394) before CPOE implementation to 6.57% (36 of 548) after CPOE implementation. Multivariate analysis revealed that CPOE remained independently associated with increased odds of mortality after adjustment for other mortality covariables.</li> </ul>

<p>Manzo <i>et al.</i><sup>34</sup> 2005</p>	<p><i>Two distinct health syetems 6 teaching hospital and 1 teaching pediatric hospital</i></p>	<ul style="list-style-type: none"> <li>• <i>Case report</i></li> <li>• <i>Non-random controlled trial (before-after), Observational.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Medication errors (S)</li> <li>• Cost(C)</li> <li>• Efficiency (C)</li> <li>• Adherance to guideline (A)</li> </ul>	<p>The introduction of CPOE resulted in:</p> <ul style="list-style-type: none"> <li>• Transformation of the traditional pharmacist role</li> <li>• Improved access to patient information, drug information, standard protocols and guidelines.</li> <li>• Reduction in time spent on non-pharmacy issues</li> <li>• Improved medication billing</li> <li>• 60% reduction in medication turn-around time</li> <li>• 50% improvement of legibility and completeness of all medication order/</li> <li>• 50% reduction in transcription and medication errors</li> <li>• Improved documentation</li> <li>• Enhanced medication formulary compliance</li> <li>• Enhanced medication cost saving due to improved medication utilization.</li> </ul>
<p>Peterson <i>et al.</i><sup>35</sup> 2005</p>	<p><i>Teaching hospital Psychotropic medications 3718 elderly patients 7456 initial orders</i></p>	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Non-random controlled trial (before-after)(off-on-off-on)</i></li> <li>• <i>24 weeks (6+6+6+6)</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Adherence to guideline (A)</li> <li>• Fall rate (O)</li> <li>• LOS (C)</li> </ul>	<ul style="list-style-type: none"> <li>• The intervention increased the prescription of the recommended daily dose (29% vs 19%; p&lt;0.001), reduced the incidence of 10-fold dosing (2.8% vs 5%; p&lt;0.001), and reduced the prescription of non-recommended drugs (10.8% vs 7.6% of total orders; p&lt;0.001).</li> <li>• Patients in the intervention cohort had a lower in-hospital fall rate (0.28 vs 0.64 falls per 100 patient-days; p=0.001)</li> <li>• No effect on hospital LOS</li> </ul>
<p>Shulman <i>et al.</i><sup>64</sup> 2005</p>	<p><i>Teaching hospital ICU 2429 electronic prescriptions 1036 hand written prescriptions</i></p>	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Non-random controlled trial (sampling before-several time point after)</i></li> <li>• <i>26 days sampling during 70 weeks (9+17)</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Medication errors (S)</li> </ul>	<ul style="list-style-type: none"> <li>• The total proportion of MEs was significantly lower with CPOE (117 errors from 2,429 prescriptions, 4.8%) than with hand written prescriptions (69 errors from 1,036 prescription, 6.7%) (p&lt;0.04).</li> <li>• The proportion of errors decreased with time following the introduction of CPOE (p&lt;0.001). Two errors caused by CPOE led to patient harm requiring an increase in length of stay and, if administrated, three prescriptions with CPOE would potentially have led to permanent harm or death. There was a reduction in major/moderate patient problems with CPOE when non-intercepted and intercepted errors were combined (p=0.01). Dose errors (16.9% vs 26.5%) and unsigned prescriptions or changes not signed/dated (14.1% vs 33.3%) were the main items which increased during the CPOE period. At the same time dose/unit/frequency omitted on prescription (31% vs 0.9%) decreased in this period.</li> </ul>

Upperman et al. <sup>65</sup> 2005	Teaching pediatric hospital 45615 patient days 8619 discharges	<ul style="list-style-type: none"> <li>Retrospective</li> <li>Non-random controlled trial (before-after)</li> <li>24 months (12+12)</li> <li>Chart review</li> </ul>	<ul style="list-style-type: none"> <li>ADEs (S)</li> <li>Transcription errors (S)</li> </ul>	<ul style="list-style-type: none"> <li>Pre-CPOE verbal order regulatory compliance was 80%, whereas post-CPOE compliance increased to 95%. Transcription errors were eliminated. All pre-CPOE ADEs were 0.3±0.04 per 1000 doses whereas post-CPOE ADEs were 0.37±0.05 per 1000 doses (p=0.3). Harmful pre-CPOE ADEs were 0.05±0.017 per 1000 doses, while post-CPOE ADEs were 0.03±0.003 per 1000 doses (p=0.05).</li> </ul>
Asaro et al. <sup>38</sup> 2006	Emergency department 218 patients	<ul style="list-style-type: none"> <li>Retrospective</li> <li>Non-random controlled trial (before-after)</li> <li>Chart review</li> </ul>	<ul style="list-style-type: none"> <li>Adherence to acute coronary syndrome (ACS) order set (A)</li> </ul>	<ul style="list-style-type: none"> <li>Use of order-sets increased over the period of study. Some association between beta-blocker use and use of CPOE order-sets was found, but there was no improvement in overall compliance with any of the patient specific guideline recommendations.</li> </ul>
Butler et al. <sup>21</sup> 2006	Teaching hospital Cardiology dept. 576 acute myocardial infarction (AMI) 1251 congestive heart failure (CHF)	<ul style="list-style-type: none"> <li>Prospective</li> <li>Non-random controlled trial (before-after)</li> <li>24 months (12+12)</li> <li>Chart review</li> </ul>	<ul style="list-style-type: none"> <li>Adherence to guideline (A)</li> </ul>	<ul style="list-style-type: none"> <li>Compliance with recommended discharge medications was high at baseline and did not change significantly. Smoking cessation counseling (43% vs 1% for CHF and 62% vs 21% for AMI) and discharge instructions for CHF (56% vs 3%) improved significantly in the CPOE period.</li> </ul>
Chisolm et al. <sup>36</sup> 2006	Pediatric hospital 790 patients with asthma	<ul style="list-style-type: none"> <li>Prospective</li> <li>Non-random controlled trial (before-after)</li> <li>24 months (10+14)</li> <li>Chart review</li> </ul>	<ul style="list-style-type: none"> <li>Adherence to asthma order set (rate of systemic corticosteroid (SCS), metered-dose inhaler &amp; pulse oximetry) (A)</li> <li>Total charges (C)</li> <li>Pharmacy charges (C)</li> <li>LOS (C)</li> </ul>	<ul style="list-style-type: none"> <li>Order set (predefine prescription) patients (intervention group) were significantly more likely to receive SCS and pulse oximetry than in the control group (p&lt;0.001). No significant differences were found in financial measures and LOS. Results from focus groups suggested that order set use would be optimized by promoting order set awareness and maximizing order set quality.</li> </ul>
Del Beccaro et al. <sup>70</sup> 2006	Pediatric ICU 2533 patients	<ul style="list-style-type: none"> <li>Prospective</li> <li>Non-random controlled trial (before-after)</li> <li>26 months (13+13)</li> <li>Chart review</li> </ul>	<ul style="list-style-type: none"> <li>Mortality rate (S)</li> </ul>	<ul style="list-style-type: none"> <li>The pre-implementation mortality rate was 4.22%, and the post-implementation mortality rate was 3.46%, representing a non-significant reduction in the risk of mortality in the post-implementation period.</li> </ul>

<p>Kim et al.<sup>66</sup> 2006</p>	<p>Teaching hospital Pediatric Oncology Dept. 343 patients 2375 orders</p>	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• 537 days (241+296)</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Errors (S)</li> </ul>	<ul style="list-style-type: none"> <li>• After CPOE implementation, daily chemotherapy orders were less likely to have improper dosing (relative risk [RR], 0.26; 95% confidence interval [CI], 0.11-0.61), incorrect dosing calculations (RR, 0.09; 95% CI, 0.03-0.34), missing cumulative dose calculations (RR, 0.32; 95% CI, 0.14-0.77), and incomplete nursing checklists (RR, 0.51; 95% CI, 0.33-0.80). There was a higher likelihood of not matching medication orders to treatment plans (RR, 5.4; 95% CI, 3.1-9.5). There was no difference in the likelihood of improper dosing on treatment plans.</li> </ul>	
<p>McAlearney et al.<sup>39</sup> 2006</p>	<p>Pediatric hospital 1016 patients</p>	<ul style="list-style-type: none"> <li>• Retrospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• 24 months (10+14)</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Adherence to asthma, post-appendectomy &amp; community-acquired pneumonia (CAP) order sets (A)</li> </ul>	<ul style="list-style-type: none"> <li>• Order set utilization varied by condition (<math>X^2 = 339.2</math>, <math>p &lt; 0.001</math>), with the asthma order set resulting in the highest rates (88.1%), followed by appendectomy order set utilization (79.4%), and substantially lower CAP order set use (21.1%). Trends in order set utilization also varied by condition. Only the asthma order set showed a trend of increased use after implementation (<math>z = -3.02</math>, <math>p = 0.002</math>). In addition, factors associated with order set utilization varied. Uses of the asthma and post-appendectomy order sets were associated with factors such as admission unit and case complexity. CAP order set utilization was associated with case complexity but not admission source.</li> </ul>	
<p>Ozdas et al.<sup>37</sup> 2006</p>	<p>Teaching hospital 540 patients 118 physicians</p>	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Non-random controlled trial (before-after)</li> <li>• 52 weeks (20+32)</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• Adherence to acute coronary syndrome (ACS) order set (early aspirin ordering &amp; beta-blocker ordering) (A)</li> </ul>	<ul style="list-style-type: none"> <li>• For all ACS admissions, the decision support tool significantly increased use of the ACS order set (<math>p = 0.009</math>). Use of the ACS order set led, within the first 24 hours of hospitalization, to a significant increase in the number of patients who received aspirin (<math>p = 0.001</math>) and a non significant increase in the number of patients who received beta-blockers (<math>p = 0.07</math>). Results for confirmed acute myocardial infarction cases demonstrated similar increases, but did not reach statistical significance.</li> </ul>	
<p>III</p>	<p>Weiner et al.<sup>45</sup> 1999</p>	<p>271 house officers, attending physicians, fellows and nurses</p>	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Observational study</li> <li>• Questionnaire</li> </ul>	<ul style="list-style-type: none"> <li>• User Satisfaction (SU)</li> <li>• Time (T)</li> <li>• Errors (S)</li> <li>• Frequency of ordering medication (C)</li> </ul>	<ul style="list-style-type: none"> <li>• Only 29% to 34% of physicians felt quality was better with CPOE; 34% to 42% reported high satisfaction.</li> <li>• 44% of house officers and 34% of attendings/fellows reported that their time with patients decreased, whereas 56% of nurses indicated that their time with patients decreased (<math>p &lt; 0.001</math>).</li> <li>• 60% of house officers and 41% of attendings/fellows indicated that errors increased, whereas 69% of nurses indicated a decrease or no change in errors. (<math>p &lt; 0.001</math>)</li> <li>• Most nurses reported no change in the frequency of ordering tests and medications with CPOE, but 61% of house officers reported an increased frequency.</li> </ul>

<p>Abookire <i>et al.</i><sup>76</sup> 2000</p>	<p><i>Tertiary care hospital</i></p>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Observational study</i></li> <li>• <i>5 years</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Allergy alerts (accepted and overridden) (AI)</li> </ul>	<ul style="list-style-type: none"> <li>• Compliance to definite drugs allergy alerts decreased from 51% to 27%.</li> <li>• Compliance to possible drugs allergy alerts decreased from 46% to 20%.</li> </ul>
<p>Oppenheim <i>et al.</i><sup>18</sup> 2002</p>	<p><i>Tertiary care hospital (Neurology, General medicine, Renal wards and ICUs) 4596 orders 21 antibiotics</i></p>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Non-controlled trial,</i></li> <li>• <i>3 months</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• % of errors in dose adjustment (S)</li> <li>• Adherence to system's alert (A)</li> </ul>	<ul style="list-style-type: none"> <li>• 37% (1,337) of orders were in patients with renal dysfunction of sufficient magnitude to require dose adjustment. True positive alerts were generated in response to 23% (304) of the orders (overall error rate). Of these, 159 (52%) orders were adjusted to the alerts. 15% (195) orders generated false positive alerts.</li> <li>• Higher error rates were observed on general medical units than in intensive care units (31% vs 23%, p&lt;0.01) and in ICUs compared with the renal unit (23% vs. 14%, p&lt;0.01). No difference in error rate was observed between experienced and inexperienced housestaff (24% vs. 20%, p=NS).</li> <li>• Experienced housestaff corrected their errors in response to alerts for a significantly greater percentage of orders than inexperienced housestaff (72% vs. 47%, p&lt;0.01).</li> </ul>
<p>Cheng <i>et al.</i><sup>72</sup> 2003</p>	<p><i>ICU (Medical and Surgical)</i></p>	<ul style="list-style-type: none"> <li>• <i>Observational qualitative study,</i></li> <li>• <i>86 hours of observation</i></li> </ul>	<ul style="list-style-type: none"> <li>• Disruptions in workflow processes (C):</li> <li>• Coordination redundancy</li> <li>• Computational interface</li> <li>• Work location</li> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>• CPOE created coordination redundancy through increasing the coordination load amongst clinicians and adding verification tasks.</li> <li>• Minor inconveniences with the computational interface resulted in adaptations to circumvent the desired safety features of the system.</li> <li>• Nurses tended to use the bedside computer. Physicians usually became aware of the need for orders whilst at the patient bedside, but would choose to travel to the work area to enter the order, so as not to disrupt the nurses' work. The cognitive load of this burden was frequently exacerbated by interruption while traveling between the bedside and work area.</li> </ul>

	<p>Mitchell <i>et al.</i><sup>44</sup> 2004</p>	<p><i>Tertiary care hospital Surgical ward, theatres and recovery 4927 electronic prescriptions</i></p>	<ul style="list-style-type: none"> <li>• <i>Prospective,</i></li> <li>• <i>Non-controlled trial</i></li> <li>• <i>13 weeks</i></li> <li>• <i>5 days non-random controlled trial</i></li> <li>• <i>Chart review and questionnaire</i></li> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>• Rate of errors (S)</li> <li>• Rate of pharmacist intervention (AI)</li> <li>• User satisfaction (SU)</li> </ul>	<ul style="list-style-type: none"> <li>• The continuous pharmacy audit of e-drug orders identified 143 (2.9%) errors. The highest error rates were seen in the first week of the project (6.4%), half of which were due to selection of the wrong formulation of the required drug. Electronic system errors peculiar to the use of Electronic Prescribing was 1.2% of total e-drug orders (57/4927) and no system errors were seen after week 8.</li> <li>• The rates of pharmacists' intervention were no different in electronic areas compared to clinical areas using hand-written prescription.</li> <li>• The user satisfaction survey demonstrated that the pilot was well regarded by healthcare staff involved in electronic prescribing.</li> </ul>
	<p>Beuscart-Zephir <i>et al.</i><sup>75</sup> 2005</p>	<p><i>1 public &amp; 2 teaching hospital</i></p>	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Usability inspection (Qualitative evaluation)</i></li> <li>• <i>Interview, Observation, chart review, video &amp; sound recording</i></li> </ul>	<ul style="list-style-type: none"> <li>• Physician's and nurses activity, communications, and cooperation (C)</li> </ul>	<ul style="list-style-type: none"> <li>• The paper-based situation is characterized by a synchronous cooperation with distributed decision making where physicians and nurses rely mostly on verbal communications to coordinate their actions; paper order sheets are weakly structured and poorly support the documentation task. In the computerized situation, physicians and nurses work in an asynchronous mode, and leave the coordination of their actions to the system. Orders are exhaustively documented but some data may be misinterpreted. Some of these problems are due to usability flaws of the Human Computer Interface.</li> </ul>
<p><b>IV</b></p>	<p>Lee <i>et al.</i><sup>83</sup> 1996</p>	<p><i>200 housestaff physicians 200 nurses</i></p>	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Observational study</i></li> <li>• <i>Questionnaire</i></li> </ul>	<ul style="list-style-type: none"> <li>• User Satisfaction (SU)</li> </ul>	<ul style="list-style-type: none"> <li>• Satisfaction score was, on scale of 1 to 7: medical house officers, 5.55; surgical house officer, 4.45; and nurses, 4.84; highest scores were given to impressions of effect on productivity, ease of use, and speed.</li> </ul>
	<p>Del Fiol <i>et al.</i><sup>41</sup> 2000</p>	<p><i>37237 prescriptions</i></p>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Observational study</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• # prescriptuions with drug-drug interactions (S)</li> </ul>	<ul style="list-style-type: none"> <li>• The system was able to detect 10,044 (27%) orders containing one or more drug-drug interactions. Among these interactions, 6.4% had high severity.</li> </ul>

Nightingale et al. <sup>42</sup> 2000	Tertiary care hospital Renal Unit 87789 prescriptions	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Observational study</li> <li>• Non-controlled trial</li> <li>• 11 months</li> <li>• Chart review and Questionnaire</li> </ul>	<ul style="list-style-type: none"> <li>• # of cancelled prescriptions (S)</li> <li>• Proportion of warning messages overridden (AI)</li> <li>• User satisfaction (SU)</li> </ul>	<ul style="list-style-type: none"> <li>• 58 (0.07%) out of 87,789 prescriptions were cancelled by the system based on clinical safety. Allergy to penicillin and cephalosporins was the main reason for canceling (34/58).</li> <li>• 427 (57%) out of 749 high level warnings and 1257 (8%) out of 16,607 low level warnings were accepted by physicians. Among high-level alerts, 85% (84/99) of interactions, 73% (103/141) of contraindications, 43% (89/206) of maximum recommended single dose, and 15% (46/303) of maximum recommended daily dose were overridden. Among low-level alerts, 93% (14635/15743) of interactions, 85% (677/793) of contraindications, 54% (25/46) of maximum recommended single dose, and 52% (13/25) of maximum recommended daily dose were overridden.</li> <li>• In a user survey, 82% (31/38) of doctors and nurses considered the system to be an improvement on conventional procedures.</li> </ul>
Murff and Kanny <sup>82</sup> 2001	144 house officers for commercially available system. 132 house officers for VA system	<ul style="list-style-type: none"> <li>• Prospective</li> <li>• Observational study</li> <li>• Questionnaire</li> </ul>	<ul style="list-style-type: none"> <li>• User Satisfaction (SU)</li> </ul>	<ul style="list-style-type: none"> <li>• Overall satisfaction: 3.67 (scale, 0-9) for commercial system and 7.21 for VA system; the highest satisfaction score was given to the ability to perform tasks in “straightforward” manner.</li> </ul>
Costa et al. <sup>80</sup> 2004	Tertiary care hospital 112 users (physicians, nurses, administrative personnel, pharmacists)	<ul style="list-style-type: none"> <li>• Observational study</li> <li>• Questionnaire</li> </ul>	<ul style="list-style-type: none"> <li>• User satisfaction (practicability, precision, information adequacy and availability) (SU)</li> </ul>	<ul style="list-style-type: none"> <li>• Users were satisfied to use the system and mention many possible benefits of thereof.</li> </ul>
Hsieh et al. <sup>43</sup> 2004	Tertiary care hospital 1150 patients 7761 alerts	<ul style="list-style-type: none"> <li>• Retrospective</li> <li>• Observational study</li> <li>• Random cases</li> <li>• 3 months,</li> <li>• Chart review</li> </ul>	<ul style="list-style-type: none"> <li>• # of alerts (AI)</li> <li>• Common reasons for overriding alerts (AI)</li> <li>• ADEs (S)</li> <li>• Completeness of patients’ allergy list</li> </ul>	<ul style="list-style-type: none"> <li>• 80% of allergy alerts were overridden (6182/7761). In this sample, only 10% of alerts were triggered by an exact match between the ordered drug and listed allergy.</li> <li>• Physicians’ most common reason for overriding alerts were “Aware/Will monitor” (55%), “Patient does not have this allergy/tolerates” (33%), and “Patient taking [drug] already” (10%).</li> <li>• In a stratified random subset of 320 patients, 19 (6%) experienced ADEs attributed to the overridden drug; of these, 9 (47%) were serious. None of the ADEs was considered preventable because the overridden alerts were deemed clinically justifiable.</li> <li>• The degree of completeness of patients’ allergy lists was highly variable and generally low in both paper charts and the CPOE system.</li> </ul>

Rosenbloom et al. <sup>81</sup> 2004	Tertiary care hospital 491 physicians, 128 medical students	<ul style="list-style-type: none"> <li>• <i>Observational study</i></li> <li>• <i>Questionnaire</i></li> </ul>	<ul style="list-style-type: none"> <li>• Satisfaction (SU)</li> <li>• Workflow efficiency inpatient</li> <li>• Quality of care</li> <li>• Laboratory result reporting</li> <li>• Embedded guideline</li> </ul>	<ul style="list-style-type: none"> <li>• 72% agree or strongly agree that CPOE improves the quality of care that they provide, 54% that the decision support usually helps them to provide quality patient care, and 62% that it improves efficiency of order entry. Respondents were least likely to say that display of prior laboratory results influenced their decision to order a subsequent test. There were no significant differences between subspecialties and by advancing years of training among housestaff. Respondents agreed that the integrated clinical decision support enhanced their medical training.</li> </ul>
Horsky et al. <sup>47</sup> 2005	Potassium Chloride (KCl)	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Observational</i></li> <li>• <i>Case report</i></li> <li>• <i>Chart review, interview</i></li> </ul>	<ul style="list-style-type: none"> <li>• Medication error (S)</li> </ul>	<ul style="list-style-type: none"> <li>• The authors characterized errors in several converging aspects of the drug ordering process that together contributed to a serious dosing error: confusing on-screen laboratory results review, system usability difficulties, user training problems, and suboptimal clinical system safeguards.</li> </ul>
Koppel et al. <sup>67</sup> 2005	Teaching hospital 5 focus groups 277 housestaff, attending physicians, and nurses 3 pharmacists 18 interview	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Mixed qualitative/quantitative methods</i></li> <li>• <i>24 months</i></li> <li>• <i>Questionnaire, interview, focus group, observation, shadowing</i></li> </ul>	<ul style="list-style-type: none"> <li>• Medication errors (S)</li> </ul>	<ul style="list-style-type: none"> <li>• CPOE facilitated 22 types of medication errors risks; errors were classified as being due to 1) fragmentation of data and failure to integrate the CPOE system with other hospital systems, and 2) flaws in human-machine interface. Use of multiple qualitative and survey methods identified and quantified error risks not previously considered, offering many opportunities for error reduction.</li> </ul>
Mirco et al. <sup>48</sup> 2005	Teaching hospital Internal Medicine Dept. 162 patients 2268 orders	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Observational</i></li> <li>• <i>2 months</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Medication errors (S)</li> </ul>	<ul style="list-style-type: none"> <li>• 73 medication errors (59 prescription errors and 14 monitoring errors) were detected and documented in 22.4% of the patients. The most common prescribing errors were deficiencies related to the right class but wrong drug (28.3%), incorrect dose (30%) and unclear orders (13.3%). Errors related to incorrect frequency of administration (5%); duplicate drug therapy (11.7%); drug interaction (1.7%) and length of therapy (3.3%) were also detected. The 14 monitoring errors detected were failures to review a prescribed regimen for appropriateness and detection of problems.</li> </ul>

Nebeker <i>et al.</i> <sup>68</sup> 2005	<i>Teaching hospital 937 admissions</i>	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Observational</i></li> <li>• <i>20 weeks</i></li> <li>• <i>Randomized sampling</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• ADEs (S)</li> </ul>	<ul style="list-style-type: none"> <li>• One quarter of the hospitalizations had at least 1 ADE. Of all ADEs (483), 9% resulted in serious harm, 22% in additional monitoring and interventions, 32% in intervention alone, and 11% in monitoring alone; 27% should have resulted in additional interventions or monitoring. Medication errors contributed to 27% of these ADEs. Errors associated with ADEs occurred in the following stages: 61% ordering, 25% monitoring, 13% administration, 1% dispensing, and 0% transcription.</li> </ul>
Thompson <i>et al.</i> <sup>46</sup> 2005	<i>18 ICUs 3 ICUs with CPOE system 854 reports</i>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Observational</i></li> <li>• <i>12 months</i></li> <li>• <i>The ICU Safety Reporting System as voluntary Web-based reporting system</i></li> </ul>	<ul style="list-style-type: none"> <li>• Errors (S)</li> </ul>	<ul style="list-style-type: none"> <li>• Based on the ICU Safety Reporting System reports, 55 incidents were related to CPOE. The majority (85%) of CPOE incidents resulted in a medication error, while 15% did not. Of the CPOE incidents that resulted in a medication error or near miss (an event that did not result in patient harm), 37 (67%) were coded as user errors, 11 (20%) as software errors, and 7 (13%) as computer malfunction. The majority (88%-98%) of CPOE events reported did not result in patient harm.</li> </ul>
Banet <i>et al.</i> <sup>79</sup> 2006	<i>Emergency department</i>	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Observational study</i></li> <li>• <i>Time and motion</i></li> <li>• <i>Questionnaire</i></li> </ul>	<ul style="list-style-type: none"> <li>• Satisfaction (SU)</li> <li>• Time (T)</li> </ul>	<ul style="list-style-type: none"> <li>• Emergency care nurses were positive about the effects of CPOE, because reporting needed less time to complete medication, laboratory, and radiology orders and less time was spent clarifying orders. Their perceptions of time spent were congruent with observations from time-motion studies. Their perceptions of time spent were congruent with observations from time-motion studies where combined computer-and-paper time and direct-patient-care time did not change significantly.</li> </ul>
Bomba <i>et al.</i> <sup>84</sup> 2006	<i>Public hospital</i>	<ul style="list-style-type: none"> <li>• <i>Prospective</i></li> <li>• <i>Case study</i></li> <li>• <i>Observational study</i></li> <li>• <i>Interview and focus group sessions</i></li> </ul>	<ul style="list-style-type: none"> <li>• Feasibility</li> </ul>	<ul style="list-style-type: none"> <li>• The implementation of an electronic prescribing decision support system was not feasible at the hospital studied due to the legacy patient administration system, low availability of information technology on the wards, differing stakeholder views, legislation, and the Independent Pricing and Regulatory Tribunal of NSW report recommendations.</li> </ul>
DuBeshter <i>et al.</i> <sup>19</sup> 2006	<i>Oncology practices from 82 sites 280047 drug administrations 16976 patients</i>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Observational</i></li> <li>• <i>12 months</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Dose limit</li> </ul>	<ul style="list-style-type: none"> <li>• The user set dose limit was exceeded in only 3% of drug administrations.</li> </ul>

Eslami <i>et al.</i> <sup>49</sup> 2006	<i>Teaching hospital ICU 392 prescriptions 253 patients</i>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Observational</i></li> <li>• <i>32 months</i></li> <li>• <i>Chart review</i></li> </ul>	<ul style="list-style-type: none"> <li>• Medication errors (S)</li> </ul>	<ul style="list-style-type: none"> <li>• There ws a high frequency (58%, 227 of 392) of prescriptions that used the CPOE system’s default dose of 240 mg/day. The dose was wrong in 73% (165) of these orders. Default orders for patients with renal insufficiency amounted to 52% (132 of 259). A total of 86% (113 of 132) of these resulted in potential ADEs compared with 53% (66 of 124) for the rest of orders (p&lt;0.0001).</li> </ul>
Kaushal <i>et al.</i> <sup>74</sup> 2006	<i>Teaching hospital</i>	<ul style="list-style-type: none"> <li>• <i>Retrospective</i></li> <li>• <i>Observational</i></li> <li>• <i>10 years</i></li> <li>• <i>Review published papers about hospital &amp; internal reports, Interview</i></li> </ul>	<ul style="list-style-type: none"> <li>• Cost (C)</li> </ul>	<ul style="list-style-type: none"> <li>• Between 1993 and 2002, the BWH spent \$11.8 million to develop, implement, and operate CPOE. Over ten years, the system saved \$28.5 million for cumulative net savings of \$16.7 million and net operating budget savings of \$9.5 million given the institutional 80% prospective reimbursement rate. The CPOE system elements that resulted in the greatest cumulative saving were renal dosing guideline, nursing time utilization, specific drug guidance, and ADE prevention.</li> </ul>

A=Adherence; S=Safety; C=Costs & [Organizational] Efficiency; Al=Alerts & Appropriate to alerts; T=time; SU=Satisfaction, Usage and Usability