

## Supplemental Digital Appendix

### Kirkpatrick Learning Outcomes, Study Design, and Quality of 27 Curricula in Quality Improvement or Patient Safety for Trainees with Evaluative Components, as Reported in Studies between 2000 and January 2009

Study	Learning Outcomes (Kirkpatrick Level)*	Study Design	Main Findings†	Strength of Findings‡
<b>Highest Kirkpatrick Learning Outcome achieved = Satisfaction (Level 1), Learner Attitudes (Level 2A), or Knowledge (Level 2B) (ten studies)</b>				
<b>Under-graduate learners (5 studies)</b>				
Newell, 2008 <sup>33</sup>	Attitudes (Level 2A)	Prospective before and after study	Improvement in attitudes towards medical errors (increased awareness of normative medical errors from 2% → 21%)	Level 2 No methodological concerns (response rate 100%), single-centered, good sample size
Gunderson, 2008 <sup>25</sup>	Knowledge (Level 2B)	Prospective before and after study	Improvement in observed disclosure of medical error (2/14 failed to include essential elements of full disclosure compared to 14/14 before the session)	Level 1 Some methodological concerns (response rate 78%), single-centered, small sample size
Moskowitz, 2007 <sup>32</sup>	Attitudes (Level 2A) Knowledge (Level 2B)	Prospective before and after study	Improvement in self-reported attitudes and knowledge on 14 of 21 questionnaire items	Level 2 Methodological concerns (post-test response rate 54%), single-centered

Ogrinc, 2007 <sup>35</sup>	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B)	Prospective clustered randomized two-group trial (early vs late intervention groups)	Low satisfaction rating (30 – 40 out of 100) Increase in QIKAT knowledge scores in intervention group (8.5 → 9.3) versus decrease in QIKAT scores in control group (8.3 → 7.9); p<0.05	Level 2 No methodological concerns (response rate 83 – 100%), single-centered, small sample size
Henley, 2002 <sup>27</sup>	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B)	Non-comparative observational study	Moderate satisfaction (50 – 60% of students felt teaching was useful) Scored 84% on a 6-item end-of-rotation quiz on QI concepts	Level 1 Methodological concerns (non-comparative design), single-centered, small sample size
<b>Post-graduate learners (4 studies)</b>				
Peters, 2008 <sup>38</sup>	Attitudes (Level 2A) Knowledge (Level 2B)	Prospective non-randomized, controlled study	Increase in test of knowledge scores from 55.2 → 59.6 compared to 50.2 → 48.3 in control group, no significant difference in attitude change pre- versus postintervention	Level 1 Methodological concerns (response rate as low as 38% in the control group), single-centered
Varkey, 2008 <sup>40</sup>	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B)	Prospective before and after study	High satisfaction (5/9 rated above average, 4/9 rated superior) Significant increase in learner QIKAT scores postrotation (11.89/15) compared to prerotation (7.33/15), p<0.004 Improvement in patient understanding of care (11% increase in number of patients who understood why tests were ordered, 12% increase in the number of patients who understood recommended treatment)	Level 1 No methodological concerns (response rate 89%), single-centered, small sample size
Djuricich, 2004 <sup>22</sup>	Attitudes (Level 2A) Knowledge (Level 2B)	Prospective before and after study	Increase in score on 5-item quiz from 48% → 89% on pre-post testing of CQI knowledge	Level 3 No methodological concerns (95% response rate), single-centered (but included 2

				different groups of residents), small sample size
Frey, 2003 <sup>23</sup>	Attitudes (Level 2A) Knowledge (Level 2B)	Non-comparative observational study	High overall confidence in knowledge and attitudes (3.5 – 4.1 out of 5)	Level 2 No methodological concerns (100% response rate), single- centered, small sample size
<b>Under-graduate and post-graduate learners (one study)</b>				
Kerfoot, 2007 <sup>29</sup>	Satisfaction (Level 1) Knowledge (Level 2B)	Prospective randomized cross- over study	High satisfaction rating (4 out of 5) Increase in MCQ test scores compared to baseline (16% increase from baseline of 58%) Knowledge sustained over 4 weeks (1% decay in MCQ test scores)	Level 5 No methodological concerns (80% response rate), multi- centered, large sample size
<b>Highest Kirkpatrick Learning Outcome Achieved = Level 3 (Behavior) or Level 4 (Clinical Process Change or Patient Benefits) (17 studies)</b>				
<b>Under-graduate learners (four studies)</b>				

Patey, 2007 <sup>37</sup>	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Behavior (Level 3)	Prospective before and after study	High satisfaction rating (4 – 5 out of 5) Improvement in some self-assessed attitudes and knowledge Majority planned to report medical errors that they make (51 out of 70, 73%)	Level 1 Methodological concerns (response rate 29% at 1-year), single-centered
Madigosky, 2006 <sup>30</sup>	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Behavior (Level 3)	Prospective before and after study	High satisfaction rating (72 – 82 out of 100) Multidirectional changes in self-reported attitudes and knowledge questionnaire items Low impact on behavior – 7% reported an error through a formal process	Level 1 Methodological concerns (response rate 55%), single-centered, small sample size
Halbach, 2005 <sup>26</sup>	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Behavior (Level 3)	Prospective before and after study	High satisfaction rating (82 – 94 out of 100) High self-reported ratings of attitudes and knowledge regarding error disclosure 21 of 307 (7%) reported having disclosed a medical error to a patient	Level 3 Some methodological concerns (response rate 54%) but sound study design, single centered, large sample size
Gould, 2002 <sup>24</sup>	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A) Patient Benefits (Level 4B)	Prospective before and after study	General dissatisfaction with chart-audit learning experience (16% positive rating) Overall improvement in 27 of 40 survey items measuring self-reported attitudes and knowledge towards CQI Increased rates of foot (51 → 70%; p<0.001) and eye (27 → 38%; p<0.001) exams on pre-post chart audits HbA1c mean value decreased from 7.7% → 7.2% on pre-post chart audits (p<0.001)	Level 1 Methodological concerns (response rate 69%), single-centered, small sample size

**Post-graduate learners (13 studies)**

Oyler, 2008 <sup>36</sup>	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Prospective before and after study	Improvement in self-assessed knowledge (comfort using PDSA cycle increased from 9% → 89%) Improvement in several processes of care (increased documentation of height for BMI screening from 11% → 88% (p=0.001), decrease in the number of “inaccurate medication lists” from 25% → 9% (p<0.001))	Level 2 No methodological concerns (response rate 82%), measured clinically important outcomes for change in clinical processes, single-centered, small sample size
Voss, 2008 <sup>42</sup>	Satisfaction (Level 1) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Non-comparative observational study, qualitative study	High satisfaction rating (4.4 – 4.7 out of 5) High self-reported knowledge scores (4.4 – 4.8 out of 5) Several QI projects implemented (no outcomes reported)	Level 1 Methodological concerns (response rate unclear), single-centered, small sample size
Bechtold, 2007 <sup>18</sup>	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Prospective before and after study	No significant change in 14 of 20 survey items related to attitude and knowledge 59% of recommendations for improvement that were identified from M&M rounds were implemented at 1-year	Level 1 Methodological concerns (post-test response rate 52%), single-centered, small sample size
Canal, 2007 <sup>19</sup>	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Prospective before and after study	Increase in self-reported attitude (3.7 → 4.4 out of 5) and knowledge (1.9 → 4.6 out of 5) scores Several QI projects implemented to reduce surgical consultation wait-times (no outcomes reported)	Level 2 No methodological concerns, but single-centered, small sample size
Varkey, 2006 <sup>41</sup>	Satisfaction (Level 1) Knowledge (Level 2B)	Prospective before and after study	High satisfaction rating (4.1 out of 5) Increase in QIKAT knowledge scores	Level 1 No significant methodological

	Clinical Process Change (Level 4A)		from 2.3 → 3.4 after intervention Improvement in medication reconciliation – increased completeness of dictated medication lists from 38 → 75% (p-value not reported)	concerns, but single-centered, very small sample size
Coyle, 2005 <sup>21</sup>	Attitudes (Level 2A) Behavior (Level 3)	Prospective before and after study	No change in mean attitude and behavior scores (medical event reporting) before and 6-months after education program	Level 1 Methodological concerns (level of significance of results not reported, 100% response rate), single-centered, small sample size
Holmboe, 2005 <sup>28</sup>	Attitudes (Level 2A) Clinical Process Change (Level 4A) Patient Benefits (Level 4B)	Prospective, non-randomized, controlled study	8 of 12 (67%) systems-based changes recommended by residents were carried through at 6 months Increased rate of monofilament testing (13% vs 1%; p=0.02) and ordering of baseline EKG (17% vs 10%; p=0.01) Change in pre-post HbA1c of -0.4% in the intervention group compared to +0.7% in the control group (p<0.001)	Level 3 No methodological concerns (92% response rate), measured clinically important outcomes for patients, single-centered, small sample size
Tomolo, 2005 <sup>39</sup>	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Non-comparative observational study	High satisfaction rating (12.3 out of 15) High self-assessment scores for knowledge (48 out of 60) Several organizational practice changes implemented (no outcomes measured)	Level 1 Methodological concerns (57% response rate, non-comparative design), single-centered, small sample size
Ogrinc, 2004 <sup>34</sup>	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Prospective non-randomized, controlled study	High satisfaction rating (4.4 – 4.7 out of 5) Increase in QIKAT knowledge scores from 9.2 → 11.4 compared to 8.2 → 8.7 in control group Several organizational practice	Level 4 No methodological concerns (100% response rate), multi-centered, small sample size

			changes implemented (no outcomes measured)	
Weingart, 2004 <sup>43</sup>	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Behavior (Level 3) Clinical Process Change (Level 4A)	Non-comparative observational study	High satisfaction rating (71 to 87% rating) Positive responder ratings for self-assessed attitudes, knowledge, 56% reported a change in behavior Several organizational practice changes with positive outcomes (i.e., 62% decrease in inappropriate use of telemetry for chest pain patients; p-value not reported)	Level 1 Methodological concerns (non-comparative study), 100% response rate, single-centered, small sample size
Ziegelstein, 2004 <sup>44</sup>	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Retrospective pre-post observational study	High satisfaction rating (76 – 92% rating) Improved self-rated scores for knowledge and attitude (1.6 → 2.5 out of 5) Organizational practice change implemented to improve mammography rates (no outcomes reported)	Level 1 Methodological concerns (66-70% response rate), single-centered, small sample size
Coleman, 2003 <sup>20</sup>	Satisfaction (Level 1) Attitudes (Level 2A) Clinical Process Change (Level 4A)	Prospective before and after study for clinical impact (non-comparative observational study for satisfaction)	Moderate satisfaction scores (60 – 70% rating) for rating of value of intervention Organizational practice changes resulted from 3 QI projects (increased completion of patient data summary sheets from 14% → 40% (p<0.001); increased screening of diabetic patients for microalbuminuria from 5% → 29% (p=0.017); increased medication list completion from 10% → 44% (p<0.001))	Level 2 No methodological concerns (response rate 79%), measured clinically important outcomes for change in organizational practice, single-centered, small sample size
Mohr, 2003 <sup>31</sup>	Clinical Process Change (Level 4A)	Prospective before and after study	Increase in childhood immunization rates from 60% → 86% (p=0.04)	Level 1 Methodological concerns (inception cohort unclear for

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chart review), single-centered,  
small sample size

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\* Learner outcomes are classified using Kirkpatrick's model<sup>16</sup>, which includes impacts on learners' satisfaction (Level 1), changes in learner attitudes (Level 2A), measures of learner knowledge and skills (Level 2B), changes in learner behavior (Level 3), changes to clinical processes (Level 4A), and benefits to patients (Level 4B).

† BMI indicates body mass index; CQI, continuous quality improvement; EKG, electrocardiogram; HbA1c, hemoglobin A1c; M&M, morbidity and mortality; MCQ, multiple choice questionnaire; PDSA, plan-do-study-act; QI, quality improvement; QIKAT, quality improvement knowledge assessment tool.

‡ Strength of findings was assessed using the Best Evidence in Medical Education (BEME) rating system<sup>15</sup> which assigns a rating of Level 1 when no clear conclusions can be drawn, Level 2 when results are ambiguous but exhibit a trend, Level 3 when conclusions can probably be based on the results, Level 4 when results are clear and very likely to be true, and Level 5 when results are unequivocal.