

## Appendix Text A. Literature Searches

The 14 studies for the previously published systematic review and meta-analysis (Meddings et al, *Clin Infect Dis*, 2010) were obtained from a comprehensive search of the world's literature for interventions from 1950 to 2008 to decrease catheter-associated urinary tract infections by means of the MEDLINE and Cochrane databases (using Ovid), the PubMed Journals and Medical Subject Heading (MeSH) datasets, the ISI Web of Knowledge databases (Web of Science and Biosis Previews) and the CINAHL and EMBASE databases. The MEDLINE and Cochrane database searches were conducted by exploding and combining the following Medical Subject Heading (MeSH) terms: *urinary tract infection, urinary catheterization, indwelling catheter, inpatient, reminder system, device removal, intervention studies*. The MeSH *reminder system* was also searched separately. We included the following terms in a keyword search (with wildcard indicated with \*): *urinary tract infection; ((urin\* or uret\*) and cath\*) or catheter\*; nosocomial or inpatient or hospital\*; reminder, removal, and intervention*. We used similar strategies with the other databases. A research librarian provided guidance to improve search completeness. This search yielded 6679 citations, including many duplicate citations. As our initial search was broad and yielded many guidelines and reviews published regarding prevention of catheter-associated urinary tract infection, we also evaluated these articles' reference lists for additional studies; 1 additional reference was located in this manner. More detailed review was required for 118 articles to determine whether they met inclusion criteria. After applying inclusion and exclusion criteria to focus on human studies of adults admitted to acute care hospitals reporting at least one outcome involving catheter use or CAUTI events as a result of the intervention, and with a comparison group (either pre- versus post-

intervention or a separate control group); this yielded 16 studies for further review. Two authors of the systematic review (J.M. and M.M.) independently reviewed and abstracted data from the 16 articles that appeared to meet inclusion criteria, including setting, study population, inclusion/exclusion criteria, definitions used, health outcomes, and quality issues. A third investigator (S.S.) resolved any differences in abstraction and reviewed the joint decisions made to exclude 2 of the 16 articles that no longer met inclusion criteria after further review. As a result, this systematic search in 2008 yielded the 14 articles reviewed in the previously published meta-analysis.<sup>1-14</sup>

To update the prior literature search for this manuscript, a search was performed of MEDLINE and Cochrane databases (using Ovid) and PubMed for intervention studies (published from August 2008 to February 2012) to reduce use of unnecessary urinary catheters in the acute care of adults, using the same detailed search strategy as employed in the 2008 search. Yet, unlike the 2008 search which was focused on removal of recently placed indwelling catheters (and which excluded emergency environments), the patient population for the 2012 search was expanded to include emergency department patients. The search was expanded because use of interventions to restrict initial placement was an additional topic of interest for this review. The 2012 search results were also supplemented with prior lists of articles excluded from the prior 2008 search that were focused on emergency department interventions. A secondary evaluation of the CINAHL database was also performed for interventions developed and implemented by nurses related to urinary catheter use. In light of the somewhat different terminology on the topic found in the nursing literature, we searched CINAHL using variations of the following terms: *reminder*, *removal*, *urinary catheter*, *nurse empowered*, *nurse directed*,

*nurse protocol*. No date limits were employed in the CINAHL search, which retrieved 5 records. Overall, the MEDLINE and CINAHL searches yielded 479 citations, including 353 from MEDLINE through Ovid, 9 additional from PubMed, 117 from the Cochrane EBM databases, and 7 duplicates. Studies were included if at least one outcome involving catheter use or CAUTI events (Appendix Table) was reported as a result of the intervention with a comparison group. A review of reference lists for additional studies was also performed, yielding one additional study. We applied inclusion and exclusion criteria to focus on human studies of adult patients with at least one outcome involving catheter use or CAUTI events reported as a result of the intervention, and with a comparison group. After applying this criteria, the updated search yielded 12 intervention studies published since the prior meta-analysis.<sup>15-26</sup>

An additional update of this literature search was performed October 23, 2012 (for literature published from February 2012 to October 23, 2012) using the same databases and search criteria that was performed in February 2012, yielding 97 additional citations for consideration. After applying the same inclusion/exclusion criteria as previously, 74 articles were excluded by title and abstract review yielding 23 studies to review further of the full text and reference lists. Of these 23 articles, 4 articles<sup>27-30</sup> were intervention studies with reminder or stop-order interventions were appropriate for inclusion (increasing the number of reminder and stop-order intervention studies to 16 since the prior meta-analysis). 1 article was a meta-analysis of bladder scanner protocols<sup>31</sup> as interventions to decrease catheter placement with a reference list that yielded 3 individual studies<sup>32-34</sup> for the Appendix Table.

## **Appendix Text B. Methods**

As summarized in the previously published meta-analysis for the 14 selected studies from 2008 or earlier, a systematic review process was performed. Correspondence with 24 authors was initiated to clarify details regarding the interventions and outcomes with responses received from 11 authors, and 4 authors provided unpublished numeric data necessary for statistical pooling. Two physician reviewers performed a detailed abstraction of the 14 studies. Details of the statistical analyses for obtaining the pooled effects are detailed in the prior published analyses, and were not replicated or expanded for writing this review.

A similar review and abstraction process was performed by one physician (J.M.) for the 16 recent articles in the updated search. Contact was initiated with authors of 3 of the most recent articles<sup>15,19,27</sup> to obtain clarification of study population characteristics and/or results data. Dr. Adams reviewed the data and confirmed and provided the correct pre and post intervention daily catheter prevalence rates (which were correct in the published text), and also provided the number of patients studied. Dr. Johnson (corresponding author for Knoll et al<sup>19</sup>) responded to our queries but could not provide the number of patients in the study groups. Dr. Bruminhent did not respond to our queries. These 16 articles were analyzed and abstracted by J.M. as potential candidates for inclusion in the updated meta-analyses, and also summarized in a narrative method in Appendix Table and Table 3.

Important outcomes of the 30 studies with reminder and/or stop order interventions (14 studies from prior meta-analysis<sup>35</sup> and 16 more recently identified studies) as previously published in the meta-analyses were summarized in Table 3.. Additional details

(study design, country of origin, patient population size, care environment, all intervention details) are summarized in the Appendix Table.

**Statistical Analyses.** Analyses were conducted using Stata/MP, version 12.1 (StataCorp). Pooled estimates were obtained using DerSimonian-Laird random effects models. Heterogeneity among studies was assessed using between-study variance ( $\tau^2$ ) and the Higgins and Thompson  $I^2$  (percentage of variability in the intervention attributable to heterogeneity). All tests were two-sided, and the type I error rate was set at 0.05.

**Appendix Table. Characteristics of Studies with Interventions to Avoid Unnecessary Urinary Catheter Use.**

Study (Country)	Study Design	Population, Total N	Interventions to avoid unnecessary catheter PLACEMENT	Interventions to prompt REMOVAL of unnecessary catheters	Other Interventions
Adams et al, 2010 <sup>27</sup> (UK)	Pre-Post	Medical (non-ICU), N=136 patients	None	<b>Stop-order, nurse-empowered:</b> Nurse-led protocol to remove all urinary catheters that did not meet criteria.	None
Andreessen et al, 2012 <sup>28</sup> (USA)	Pre-post	Med-Surg (unclear if ICU). N=141 patients	Computerized UC order required selection of an appropriate UC indication  Promoted use of alternatives for indwelling UCs  Bladder scanner protocol.	<b>Stop-order:</b> Automated computer stop order directed at physicians/providers, requiring reassessment and re-ordering every 24 hours, or discontinues use of catheter.	Bundle included UC care steps, standardized UC kits. Computer documentation of placement and maintenance care.
Apisarntharak et al, 2007 <sup>1</sup> (Thailand)	Pre-Post	All Inpatients, N=2412 patients	None	<b>Reminder:</b> Nurse-generated daily bedside verbal reminders to encourage physicians to remove unnecessary UC.	None
Bruminhent et al, 2010 <sup>15</sup> (USA)	Pre-Post	Med-Surg: Ward + ICU, N=400 patients	None	<b>Reminder:</b> Sticker applied to medical record to remind physicians to discontinue unnecessary UCs.	None
Cornia et al, 2003 <sup>2</sup> (USA)	Non-randomized crossover trial	Medical (non-ICU), N=70 patients	Computerized UC order required selection of an appropriate UC indication	<b>Stop order:</b> Computer-generated stop order for physicians to discontinue/renew UC order 72 hours after placement.	UC care education
Crouzet et al, 2007 <sup>3</sup> (France)	Pre-Post	All Inpatients, N=234 patients	None	<b>Reminder:</b> Daily reminders from nurses to physicians to remove unnecessary UC >=4 days after insertion.	None
Dumigan et al, 1998 <sup>4</sup> (USA)	Pre-Post	ICU: Med-Surg, N=27103 patient-days	Guideline for appropriate UC indications	<b>Stop order, nurse-empowered:</b> Daily use of UC indication protocol by nurse empowered to remove UC no longer meeting criteria without requesting physician order.	UC care education

Elpern et al, 2009 <sup>16</sup> (USA)	Pre-Post	ICU: Medical, N=337 patients	Appropriate indications for UC insertion were emphasized, and list of inappropriate reasons to insert was provided	<b>Reminder:</b> Daily review by nurses for UC indication to make recommendations for removal; removal required physician order.	None
Fakih et al, 2008 <sup>5</sup> (USA)	Pre-Post with concurrent controls	Med-Surg (non-ICU) N=3736 intervention patient-days, and 4041 control patient-days	None	<b>Reminder:</b> Nurse generated reminder to physician to remove UC when no appropriate indication.	None
Fakih et al, 2010 <sup>36</sup> (USA)	Pre-Post	ED, N=322 patients had UCs placed, of 2517 ED patients in sample	Institutional guidelines for appropriate UC placement, ED physician education regarding UC utilization	None	None
Fakih et al, 2012 <sup>37</sup> (USA)	Pre-Post	Statewide, N=163 inpatient units in 71 hospitals	Education intervention to promote adherence to appropriate UC indications	None	None
Frederickson et al, 2000 <sup>33</sup> (USA)	Pre-post by concurrent controls	Surgery N=103	Bladder ultrasound program compared with standard care by ISCs	None	None
Fuchs et al, 2011 <sup>17</sup> (USA)	Pre-Post	ICU: Med-Surg, N=not provided	Urinary retention protocol, including use of bladder scanner  Procedure-specific protocols for appropriate indications for UC placement	<b>Stop order:</b> Daily checklist for evaluating UCs; when not indicated, physician order was requested for removal.  <b>Stop order:</b> Procedure-specific protocols for UC removal.	None
Gokula et al, 2007 <sup>38</sup> (USA)	Pre-Post	ED, N=200 patients with UCs placed in ED	UC indication checklist attached to UC kits	None	None
Gotelli et al, 2008 <sup>18</sup> (USA)	Pre-Post	Medical (not ICU), N=not provided	None	<b>Stop order, nurse-empowered:</b> Nurses were empowered to assess UC need by protocol and remove if not indicated.	None

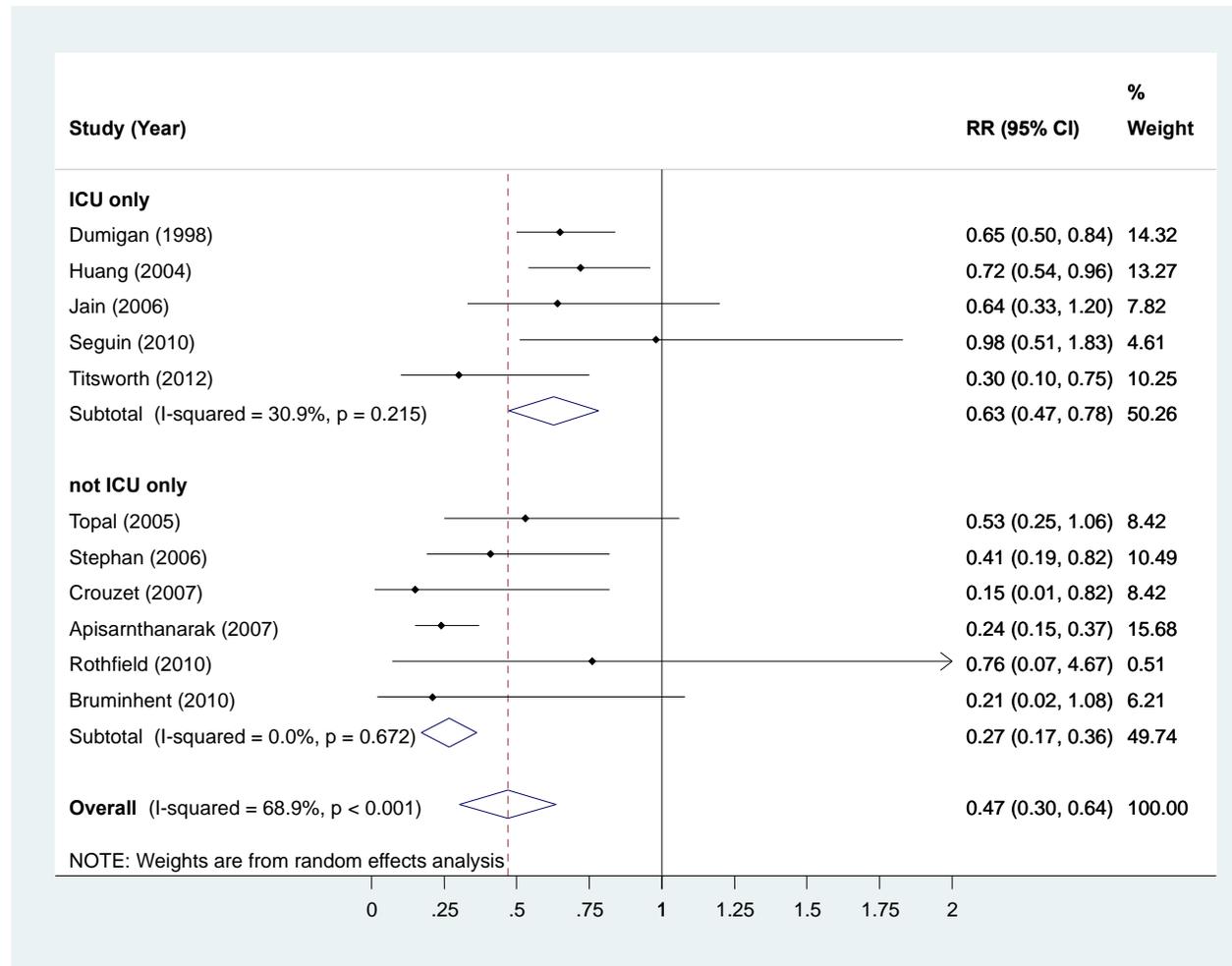
Huang et al, 2004 <sup>6</sup> (Taiwan)	Pre-Post	ICU: Med-Surg, N=6297 patients	None	<b>Reminder:</b> Nurse generated daily reminder to physician to remove unnecessary UC 5 days after insertion.	None
Jain et al, 2006 <sup>7</sup> (USA)	Pre-Post	ICU: Med-Surg, N=13471 catheter-days	None	<b>Reminder:</b> Daily use of checklist in multidisciplinary rounds to determine if UC still indicated, then nurse contacted physician for order to removal UC if no longer indicated.	Bundle included UC care steps, selected use of silver-alloy UC.
Knoll et al, 2011 <sup>19</sup> (USA)	Pre-Post	All Inpatients, N=112,140 patient-days	Educational interventions about an approved hospital list of UC indications  Computer UC order template with indication	<b>Stop order:</b> Computerized order for UC with indications and 72 h default stop date.  <b>Reminder:</b> ICU daily checklist for UC necessity.	Bundle included UC care education, dedicated UC nurse.
Lee et al, 2007 <sup>32</sup> (Taiwan)	Pre-Post	Surgery (Neurosurgery) N=244 patients	Bladder ultrasound program	None	None
Loeb et al, 2008 <sup>8</sup> (Canada)	RCT	Medical (non-ICU), N=692 patients	None	<b>Stop order, nurse-empowered:</b> Pre-written in chart for nurses empowered to discontinue UC based on criteria without an additional physician order.	None
Murphy et al, 2007 <sup>9</sup> (USA)	Pre-Post	Not explained, N=Not provided	None	<b>Reminder:</b> Foley bag sticker with time/date of insertion to remind to nurse to notify physician when Foley in place >48h in order to request removal.	UC care education
Patrizzi et al, 2009 <sup>39</sup> (USA)	Pre-Post	ED, N=Not provided	Computerized ED UC order with indications, UC alternatives promoted, urinary retention protocol with bladder scanner use	None	None
Reilly et al, 2008 <sup>10</sup> (USA)	Pre-Post	ICU: Med-Surg, N=207 patients	Developed criteria for appropriate UC placement in ICU, implemented with educational interventions regarding UC indications, and urinary retention protocol	<b>Reminder:</b> Daily use of checklist of appropriate UC indications by nurse, reminding nurse to contact physician to recommend UC removal.	UC care education

Robinson et al, 2007 <sup>20</sup> (USA)	Pre-Post	Med-Surg (non-ICU), N=69 patients		<b>Stop order:</b> Nurse identified patients without appropriate indications, then requested removal order from physicians.	None
Roser et al, 2012 <sup>29</sup> (USA)	Pre-Post	Med-Surg (including ICU), N=not provided	Educational intervention described regarding appropriate reasons for insertion	<b>Stop order, nurse empowered:</b> nurse driven urinary catheter removal protocol, empowering removal of urinary catheter within 24 hours unless contraindicated.	AHRQ CUSP program to end all healthcare associated infections.
Rothfeld et al, 2010 <sup>21</sup> (USA)	Pre-Post	Medical ICU step-down unit, N=99 patients	Developed list of appropriate indications for which UCs could be requested by nurses	<b>Stop order:</b> Nurses asked physicians for order to remove UCs when not indicated.	None
Saint et al, 2005 <sup>11</sup> (USA)	Pre-Post with concurrent nonequivalent controls	Intervention Group: Medical, Control Group: Surgery. N=3027 patients	None	<b>Reminder:</b> Study nurse generated sticker placed in chart reminding physician to generate stop order after 48 hours of UC use if no longer needed.	None
Schultz et al, 2011 <sup>22</sup> (USA)	Pre-Post	ICU: unclear type, N=Not provided	Urinary retention protocol, including use of bladder scanner	<b>Stop order, nurse-empowered:</b> Nurses were empowered to insert and remove UCs by protocol.	None
Seguin et al, 2010 <sup>23</sup> (France)	Pre-Post	ICU: Surgical, N=1271 patients	None	<b>Stop order:</b> Daily assessment required by physicians to assess if UC is needed or not; when categorized as not indicated, then removed by nurses.	None
Slappendel & Weber, 1999 <sup>34</sup> (Netherlands)	Pre-Post	Surgery: Ward + ICU N=4116 patients	Bladder ultrasound program	None	None
Stephan et al, 2006 <sup>12</sup> (Switzerland)	Pre-Post with concurrent nonequivalent controls	Surgery: Ward+ICU <u>Intervention:</u> Orthopedic, N=539 <u>Control:</u> Abdominal, N=489	UC placement restrictions, urinary retention protocol	<b>Stop order:</b> Pre-operative written order to remove UC on post-operative day 1 or 2, depending on surgery.	UC care education

Titsworth et al, 2012 <sup>30</sup> (USA)	Pre-Post	ICU (Neurologic)	UTI bundle included insertion criteria and promotion of UC alternatives including bladder scanning use.	<b>Stop order:</b> post-op removal of catheters by default by nurses if not explicitly ordered.  <b>Reminder:</b> daily Foley rounds in ICU by nurses; if no clear indication found, patient name given to critical care medicine attending as reminder to place catheter removal order if no indication found.	Bladder Bundle: UC care steps, standardized UC kits. Modules for sterile catheter technique, antimicrobial catheters
Topal et al, 2005 <sup>13</sup> (USA)	Pre-Post	Medical (non-ICU), N = 245 patients	Urinary retention protocol including bladder scanner	<b>Stop order:</b> Computerized order entry system order to prompt physicians to remove/re-order UC if placed in ED or in place >48 hours.  <b>Stop order, nurse-empowered:</b> Nurses were also empowered to remove UCs no longer needed by protocol criteria.	UC care education
van den Broek et al, 2011 <sup>24</sup> (Netherlands)	Pre-Post	All Inpatients, in 5 hospitals, N=2943 patients	Bladder scanner protocol in 2 hospitals	<u>Intervention varied by hospital:</u> <b>Reminders:</b> Used by 4 hospitals, placed in patient's record.  <b>Stop order:</b> Fixed order for removal, employed by 1 hospital.	Specially trained UC nurse
Voss, 2009 <sup>25</sup> (USA)	Pre-Post	Medical (non-ICU), N=187 patients age 65 or older	None	<b>Stop order, nurse-empowered:</b> Daily assessment by nurse for UC indications, with authority for nurse to remove if not indicated.	None
Weitzel, 2008 <sup>14</sup> (USA)	Pre-Post	Medical (unclear if ICU), N=50 patients	None	<b>Reminder:</b> Daily use of protocol by nurse to review if UC still indicated, unclear if protocol allowed for UC removal without physician order.	None
Wenger, 2010 <sup>26</sup> (USA)	Pre-Post	All Inpatients, N=Not provided	None	<b>Stop order, nurse-empowered:</b> Daily assessment by nurse of UC necessity, with authority to remove if not indicated.	UC care education, silver-alloy UC

ICU=intensive care unit; UC=urinary catheter; UTI=urinary tract infection

**Appendix Figure 1.** Meta-analysis of rate ratios (RRs) for catheter-associated urinary tract infection (CAUTI) episodes per 1000 catheter days, for intervention vs. control groups, stratified by focus on intensive care units (ICUs). CI, confidence interval



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