**Supplemental Tables**

**Supplemental Table 1.** Methodological Quality of Included Studies, by Modified Quality Indexa

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| --- | --- | --- | --- | --- | --- | --- | --- |
| First Author, year | Reporting Quality(0-11)\* | External Validity(0-3)\* | Internal Validity for Bias Measurement of Intervention(s) and Outcome(s)(0-7)\* | Internal Validity for Confounding:Bias in Selection of Study Subjects(0-6)\* | Power(0-1)\* | Overall Quality Score(0-28)\* | Report Type |
| Ahlbrecht, 1999[2](#_ENREF_2) | 4 | 3 | 1 | 0 | 1 | 9 | Published |
| Brownhill, 2013[3](#_ENREF_3) | 5.4 | 3 | 5 | 1 | 0 | 14.4 | Published, and additional unpublished data from author |
| Cools, 1988[4](#_ENREF_4) | 4.8 | 3 | 4 | 1 | 0 | 12.8 | Published |
| Darouiche, 2006[5](#_ENREF_5) | 11 | 1 | 5 | 4 | 0 | 21 | Published |
| Evans, 2013[6](#_ENREF_6) | 4 | 2 | 3 | 1 | 0 | 10 | Published |
| Fendler, 2002[7](#_ENREF_7) | 5 | 2 | 3 | 1 | 0 | 11 | Published |
| Klay, 2005[8](#_ENREF_8) | 5.4 | 1 | 3 | 1 | 0 | 10.4 | Published |
| Lin, 2013[9](#_ENREF_9) | 10 | 3 | 5 | 2 | 1 | 21 | Published |
| McConnell, 1984[10](#_ENREF_10) | 4 | 3 | 1 | 0 | 0 | 8 | Published |
| Mentes, 2003[11](#_ENREF_11) | 8.4 | 1 | 6 | 4 | 0 | 19.4 | Published |
| Miller, 2014[12](#_ENREF_12) | 10 | 3 | 7 | 4 | 1 | 25 | Published |
| Mody, 2013[13](#_ENREF_13) | 11 | 3 | 5 | 4 | 1 | 24 | Published |
| Priefer, 1982[14](#_ENREF_14) | 9.8 | 0 | 5 | 5 | 0 | 19.8 | Published |
| Saint, 2006[15](#_ENREF_15) | 10.8 | 3 | 3 | 6 | 1 | 23.8 | Published |
| Suardi, 2001[16](#_ENREF_16) | 6.8 | 0 | 5 | 3 | 1 | 15.8 | Published |
| Stuart, 2015[17](#_ENREF_17) | 6 | 3 | 4 | 1 | 1 | 15 | Published |
| Tang, 2006[18](#_ENREF_18) | 9.8 | 1 | 4 | 4 | 0 | 18.8 | Published |
| van Gaal, 2011[19](#_ENREF_19) | 5.4 | 1 | 4 | 2 | 0 | 12.4 | Published |
| Yeung, 2011[20](#_ENREF_20) | 7 | 1 | 3 | 3 | 0 | 14 | Published |

aIndicates range of score possible by modified quality index.

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| **Supplemental Table 2.** Intervention Details as Reported in the Included Studies |
| First Author, year | Reported Details of Intervention | Duration of Study/Measures |
| Ahlbrecht, 1999[21](#_ENREF_21) | Multiple interventionsInfection-control program implementation (based on guideline by Association for Professionals in Infection Control and Epidemiology): prospective infection surveillance (including UTIs, based on 1991 McGeer's criteria[22](#_ENREF_22) that specifies UTIs reported should include only symptomatic UTIs, with specific criteria for catheterized and noncatheterized patients) by facility infection control practitioner by “walk rounds” Monday to Friday, outbreak detection, isolation/precautions system, infection control policies and procedures, in-service education, resident and employee health program (vaccines, TB screen), antibiotic review, investigation/control, disease reporting to public agencies  Infection surveillance data were frequently fed back to the nursing stations (even daily) to improve the quality of resident assessments and other aspects of infection control. Environmental issues such as hand washing facilities were addressed in written policies and procedures. Resident care guidelines such as frequent turning, maintenance of personal hygiene, prompt management of pressure sores, urinary tract and intravenous catheter management, immunizations, and aspiration precautions were implemented.  Ongoing education of nursing staff regarding UTI definitions and focus on objective signs/symptoms, use of catheterized specimens, elimination of follow-up urinalysis/urine cultures in the absence of signs/symptoms. In-service programs involve topics of UTI, including UTI workshop with case studies and surveillance, and topics of fluoroquinolone antimicrobial agents and antimicrobial resistance.  | Pre-intervention: reported from pooling 3 quarterly rates from September 1992-May 1993Postintervention: reported from pooling 5 quarterly rates from June 1993-August 1994 |
| Brownhill, 2013[3](#_ENREF_3) | Multiple interventionsProgram focused on 3 areas: fall prevention, pressure ulcer prevention, and continence promotion.The continence promotion program included workshop-based training on incontinence care and product selection, education on urinary catheter care, security, and taking catheter samples, different options for catheter leg and night bags, and UTI-symptom recognition, diagnosis, and use of antibiotics. Training sessions were split into 3 categories: UTI assessment and prevention, catheter maintenance training, and recognition and assessment of incontinence. Training was focused on nonprofessional staff; 75% of staff attended training. Unpublished details of the training and outcomes were provided by the author.  | Pre-intervention: reported from averaging monthly rates from March 2011-May 2011Intervention training: June 2011-July 2011 Postintervention: August 2011-March 2012 |
| Cools, 1988 [4](#_ENREF_4)  | Multiple interventionsInfection control program initiated in 1981, with data reported form 1981-1987 Strict hand-washing routine was implemented for all personnel.  Restriction of long-term indwelling urethral catheterization: removed most catheters upon admission of hospital patients, using only intermittent catheterization in cases of acute urinary retention and supplying diapers for incontinent patients; stimulated use of toilet even for incontinent patients Antibiotic prescribing: physicians agreed to prescribe for suspected UTIs ONLY when at least 3 of the following signs/symptoms were present: frequency, strangury, abdominal pain, fever, increasing incontinence for urine, foul smelling and gritty urine. Restricted list of antibiotics used. Weekly meeting of physicians to discuss patients including infection data, bacteriology, use of antibiotics, and discussion of new patients Others: use of chairs to avoid long-term bed confinement, exercise, and physiotherapy to promote ventilation, restrict IV infusions and invasive procedures. | Reports outcomes for 6 years (1981-1987); not clear when various features of program were implemented (year 1 not clearly control/pre-intervention data)Urine testing: urine was analyzed upon admission to the center (ie, collected once without symptom criteria) and in event of clinical signs and symptoms of UTI. Leukocyturia defined as >10 WBCs/field in sediment. Bacteriuria defined as >105 CFU of single species voided or 1-2 species in catheter-drained urine. Contaminated specimen if >105 CFU of ≥2 species or voided urine or ≥3 catheter-drained urine. |
| Darouiche, 2006[5](#_ENREF_5)  | Single interventionRCT comparing StatLock device (C. R. Bard, Inc., Covington, Georgia) vs. traditional methods (tape, Velcro, Cath Secure [M. C. Johnson Company, Inc., Fenton, Missouri]) to secure indwelling transurethral or suprapubic bladder catheters. All securing devices were changed weekly. Catheters were changed at enrollment and every 4 weeks (per pre-existing hospital practices) or earlier if catheter blockage. Nurses cleansed catheterized area daily with soap and water.  | 8 weeks  |
| Evans, 2013[6](#_ENREF_6)  | Multiple interventionsMRSA bundle: universal MRSA nasal surveillance on admission/transfer/discharge; contact precautions for MRSA infection or colonization; hand-hygiene emphasis, “institutional culture change where infection control because everyone’s responsibility” including staff and leadership engagement, and use of methodologies such as “positive deviance” | 45-month period: bundle implemented October 2007; follow-up through June 2011 |
| Fendler, 2002[7](#_ENREF_7) | Single interventionAlcohol hand sanitizer gel used by caregivers in 2 units = floors of the facility (instructed to use hand sanitizer gel instead of hand washing between residents, for procedures and before medication administration unless hands were physically soiled; also instructed to wash hands with antimicrobial lotion soap after every 5 uses of hand sanitizer gel, with remainder units serving as control group (using only antimicrobial lotion soap for hand washing) | 34 months (July 1997-May 2000) |
| Klay, 2005[8](#_ENREF_8)  | Multiple interventionsAdvanced practice registered nurse continence specialist assessed each female LTC resident with incontinence to provide an individualized treatment plan, then re-evaluated quarterly for incontinence episodes, UTIs, pressure ulcers, falls and cost of care. Interventions included treatments based on type of incontinence by exam and history, including anticholinergics, topical estrogen (Estring [Pfizer Inc, New York, New York]), pelvic floor muscle exercises, dietary changes (no caffeine, more fluid and fiber), medication changes (regarding diuretics, hypnotics), and prompted toileting.  | UTIs were assessed 1 year prior and 1 year after intervention by incontinence specialist |
| Lin, 2013[9](#_ENREF_9) | Single intervention Increased fluid regimen (residents advised to increase daily fluids 1500 mL or greater, with type of beverage not restricted) vs. maintenance control group | 6 weeks |
| McConnell, 1984[10](#_ENREF_10)  | Multiple interventions Nursing interventions including a hydration program (1400 mL fluid offered with daily meals, and water and juice served between meals and at bedtime), ambulation program (twice daily assisted walking, with poster showing each resident’s accomplishments), toileting program (prompted toileting, discouraged bedpans, and used disposable incontinence products), education of staff and residents regarding purpose and goals of interventions. Physicians were encouraged to discontinue all unnecessary catheters including asking to discontinue Foley catheters for all residents admitted from hospital after short period of bladder retraining. | 6 months after nursing interventions in complete effect, retrospective survey of entire 12 months; numbers of UTIs as outcomes are reported monthly from June 1982-July 1983, with nursing measures to prevent UTIs “implemented fully” in December 1982; no summary pre/post UTI rates given beyond monthly rates |
| Mentes, 2003[11](#_ENREF_11)  | Single intervention Hydration intervention (with weight-based daily individual fluid goals, administered by multiple scheduled fluid rounds) to reduce hydration-linked events of UTI, acute confusion, respiratory infections | 8 weeks |
| Miller, 2014[23](#_ENREF_23) | Multiple interventions This study examined how the introduction of culture change practices (assessed by 19-survey items in a survey of directors of nursing and nursing home administrators) and the degree of practice implementation were associated with changes in certain care processes and outcomes. Of interest to this systematic review, percentage of residents on bladder training program (as a process of care, reported in the Online Survey, Certification and Reporting (OSCAR) dataset and percentage of residents with urinary tract infection in the last 30 days as reported in the Minimum Data Set (MDS) were study outcomes variables assessed.  | Year of introduction of culture change varied by nursing home; study outcomes were assessed the year before, of, and after culture change practice introduction.  |
| Mody, 2015[24](#_ENREF_24) | Multiple interventions MDRO active surveillance, preemptive barrier precautions, hand hygiene promotion, staff education. Intervention group: individuals with an indwelling device (regardless of MDRO status) were placed on preemptive barrier precautions for the duration of participation. Healthcare workers were encouraged to perform hand hygiene before and after providing any care to the participants and were encouraged to wear gowns and gloves when performing morning and evening care, device care, and during any activity where splashing may occur. | Enrollment over 3 years |
| Priefer, 1982[14](#_ENREF_14)  | Single intervention Comparison of group 1 (control) with indwelling catheter change only for obstruction/infection with group 2 (experimental) with indwelling catheter change monthly in addition to obstruction/infection. Irrigation was discouraged although periodically performed at discretion of nurses. All had standard daily catheter care. | 6 months |
| Saint, 2006[15](#_ENREF_15) | Single intervention Randomized trial of indwelling Foley vs. condom catheterization | Recruited August 1997-March 2001, followed during hospitalization with median of 3 days |
| Stuart, 2015[17](#_ENREF_17) | Multiple interventions Infection control clinical nurse consultant performed multiple roles:1) intermediary between the prescribing general practitioners and off-site infectious diseases physician; 2) education of nursing staff and general practitioners (small lectures, posters on wards detailing importance of using antibiotics wisely, and education campaigns targeting management of urinary sepsis in residents (not treating asymptomatic bacteriuria, decreasing duration of prescribed antibiotics for urinary sepsis); 3) data collection; 4) monitoring of pathology results via review of incoming paper results; 5) facilitate discussions between general practitioners and infectious diseases physician | 3 month pre-intervention period, September-November 2012Intervention phase began December 2012,3-month postintervention data collection period, May-July 2013 |
| Suardi, 2001[16](#_ENREF_16) | Multiple intervention: bladder scanner use and specified protocol for when to catheterize“time-volume dependent catheterization” intervention: measured bladder volume at pre-set times (using bladder scanner) and proceeding with catheterization with single-use catheters when volumes measured are in “ideal range.” This intervention was compared to intermittent catheterization at fixed times without bladder volume measurement by ultrasound.  | Recruitment over 17 months (November 1998-March 2000); data collected for each patient >14 days including 7 days of intermittent catheterization and 7 days of time-volume dependent catheterization using bladder scanner |
| Tang, 2006[18](#_ENREF_18) | Multiple interventions: bladder scanner with 2 different urinary retention management strategiesIf postvoiding residual (postvoid residual) remained ≥ 300 mL, patients were randomized to intermittent catheterization vs. indwelling urinary catheter to manage urinary retention in females in geriatric rehabilitation ward. For intermittent catheterization group, postvoid residual was monitored by bladder scan 3 times daily. Intermittent catheterization would be performed when postvoid residual ≥500 if asymptomatic or postvoid residual ≥300 mL if symptomatic. For indwelling catheter group, catheter was trial removed at least once weekly and re-inserted if postvoid residual ≥300 mL. If catheter came out successfully, postvoid residual would be monitored by bladder scanner daily until day 14. To both groups (so not intervention of study): all patients having indwelling catheters at admission had catheters removed routinely, and conservative management of regular voiding, double-voiding, and relieving constipation was started for 2 days in all cases, and all catheterizations were performed by aseptic technique by nursing staff.  | 2 weeks (14 days) |
| Van Gaal, 2011[19](#_ENREF_19), [25](#_ENREF_25) | Multiple interventions: “SAFE or SORRY?” patient safety program regarding nursing care related to adverse events of pressure ulcers, UTIs, and falls Implemented on each ward by ward manager and 2 key nurses, with implementation plan by wardEducation: 1) small-scale educational meetings for nurses (1.5 hour) on causes, assessment and prevention of adverse events, 2) 2 case discussions per ward (30 minutes) when nurse and research reviewed patients on ward regarding causes, risk, and prevention of adverse events, 3) CD-ROM education material including test to check and feedback nurse knowledge of adverse eventsPatient involvement: including information by leaflet and orally from nurses regarding prevention of these adverse events to patients at risk for specific adverse eventsFeedback though computerized registration program (on process and outcome measures entered daily by nurses) including daily feedback on UTI outcomes and weekly feedback of measurement of very specific UTI preventive care issues for patients with and without a catheter, including hand hygiene before/after care moments and gloves when emptying bag, toileting if no catheter, correct indication and duration of indwelling catheters, secured catheter to leg, correct use of urinary catheter bag | September 2006-November 2008, 3 month baseline period; 14-month intervention implementation period, then 9-month postintervention follow-up period for measurements |
| Yeung, 2011[20](#_ENREF_20) | Single intervention: hand hygiene programAlcohol-based hand rub in pocket-size containers, 2-hour seminar on hand hygiene (provided at 3 seminar opportunities including indications, proper method, and importance of antiseptic hand rubbing and hand washing; each staff member was requested to attend 1 seminar), posters and ballpoint pens designed as reminders of hand hygiene  | 3-month pre-intervention period, 2-week intervention period, 7-month postintervention period |

NOTE: Abbreviations: CAUTI, catheter-associated urinary tract infection; CFU, colony-forming unit; IC, infection control; LTC, long-term care; MRSA: methicillin-resistant *S. aureus*; MDRO: multidrug resistant organism; RCT, randomized controlled trial; TB, tuberculosis; UTI, urinary tract infections; WBC, white blood cells.

**Supplemental TABLE 3.** Published definitions of CAUTI

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Criteria | NHSN-LTCF[**3**](#_ENREF_3) | NHSN-Acute Care[**26**](#_ENREF_26) | McGeer’s, Revised 2012[**27**](#_ENREF_27) | McGeer’s, 1991[**22**](#_ENREF_22) | Loeb Minimum Criteria[**28**](#_ENREF_28) |
| Symptoms |  |  |  |  |  |
| Rigors/chills | + | - | + | + | + |
| Purulent discharge around catheter site | + | - | + | - | - |
| Acute functional decline | + | - | + | + | - |
| Acute change in mental status | + | - | + | + | + |
| Change in character of urine | - | - | - | + | - |
| Signs |  |  |  |  |  |
| Fever |  |  |  |  |  |
| > 37.8° C, single oral | + | - | + | - | - |
| > 37.9° C, single any site | - | - | - | - | + |
| > 38.0° C, single any site | - | + | - | + | - |
| > 37.2° C, repeated oral | + | - | + | - | - |
| > 37.5° C, repeated rectal | + | - | + | - | - |
| > 1.1° C over baseline, single any site | + | - | + | - | - |
| ≥ 1.5° C over baseline, single any site | - | - | - | - | + |
| New hypotension | + | - | + | - | - |
| Signs or Symptoms |  |  |  |  |  |
| New onset suprapubic pain or tenderness | + | + | + | + | - |
| New onset costovertebral pain or tenderness | + | + | + | - | + |
| New flank pain or tenderness | - | - | - | + | - |
| Acute pain, swelling or tenderness of testes, epididymis, or prostate | + | - | + | - | - |
| Laboratory Findings |  |  |  |  |  |
| Leukocytosis (WBC >14,000/mm3) or left shift (> 6% or 1500 bands/mm3) | + | - | + | - | - |
| Positive urine culture with >105 CFU/ml of ≤2 organism(s), specimen from clean catch or indwelling catheter | + | + | - | - | - |
| Positive urine culture with >105 CFU/ml of any number of organism(s), specimen from indwelling catheter | + | - | + | - | - |
| Positive urine culture with >102 CFU/ml of any number of organism(s), specimen from in/out catheter  | + | - | - | - | - |
| Positive urine culture with ≥103 and <105 CFU/ml with ≤2 organism(s), specimen from clean catch or indwelling catheter | - | + | - | - | - |
| Positive dipstick for leukocyte esterase and/or nitrate | - | + | - | - | - |
| Pyuria (≥10 WBC/mm3 unspun urine; > 5 WBC/hpf spun urine) | - | + | - | - | - |
| Microorganisms on Gram stain, unspun urine | - | + | - | - | - |

NOTE: Abbreviations: CAUTI, catheter-associated urinary tract infection; CFU, colony-forming unit; NHSN, National Healthcare Safety Network; LTCF, long-term care facilities, WBC, white blood cell.

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