HICPAC
HEALTHCARE INFECTION CONTROL PRACTICES ADVISORY COMMITTEE

GUIDELINE FOR PREVENTION OF CATHETER-ASSOCIATED URINARY TRACT INFECTIONS 2009

Carolyn V. Gould, MD, MSCR [1]; Craig A. Umscheid, MD, MSCE [2]; Rajender K. Agarwal, MD, MPH [2]; Gretchen Kuntz, MSW, MSLIS [2]; David A. Pegues, MD [3] and the Healthcare Infection Control Practices Advisory Committee (HICPAC) [4]

[1] Division of Healthcare Quality Promotion
Centers for Disease Control and Prevention
Atlanta, GA

[2] Center for Evidence-based Practice
University of Pennsylvania Health System
Philadelphia, PA

[3] Division of Infectious Diseases
David Geffen School of Medicine at UCLA
Los Angeles, CA

[4]Healthcare Infection Control Practices Advisory Committee (HICPAC)

Chair

BRENNAN, Patrick J., MD
Chief Medical Officer
Division of Infectious Diseases
University of Pennsylvania Health System

Executive Secretary

BELL, Michael R., MD
Associate Director for Infection Control
Division of Healthcare Quality Promotion
National Center for Infectious Diseases
Centers for Disease Control and Prevention

Members

BURNS, Lillian A., MPH
Infection Control Coordinator
Infectious Diseases Department,
Greenwich Hospital

ELWARD, Alexis, MD, MPH
Medical Director of Infection Control
Assistant Professor, Pediatric Infectious Diseases
Washington University School of Medicine

ENGEL, Jeffrey, MD
Chief, Epidemiology Section, North Carolina Division of Public Health
North Carolina State Epidemiologist

LUNDSTROM, Tammy, MD, JD
Chief Medical Officer
Providence Hospital

GORDON, Steven M., MD
Chairman, Department of Infectious Diseases
Hospital Epidemiologist
Cleveland Clinic Foundation

MCCARTER, Yvette S., PhD
Director, Clinical Microbiology Laboratory
Department of Pathology
University of Florida Health Science Center-Jacksonville

MURPHY, Denise M., MPH, RN, CIC
Vice President, Safety and Quality
Barnes-Jewish Hospital at Washington University Medical Center

OLMSTED, Russell N., MPH
Epidemiologist
Infection Control Services
St. Joseph Mercy Health System

PEGUES, David Alexander, MD
Professor of Medicine, Hospital Epidemiologist
David Geffen School of Medicine at UCLA

RAMSEY, Keith M., MD
Professor of Medicine
Medical Director of Infection Control
Pitt County Memorial

SINGH, Nalini, MD, MPH
Professor of Pediatrics
Epidemiology and International Health
George Washington University
Children's National Medical Center

SOULE, Barbara M., RN, MPA, CIC
Practice Leader
Infection Prevention Services
Joint Commission Resources/Joint Commission International

SCHECTER, William, P., MD
Department of Surgery, Ward 3A 17
San Francisco General Hospital

STEVENSON, Kurt Brown, MD, MPH
Division of Infectious Diseases
Department of Internal Medicine
The Ohio State University Medical Center

Ex-officio Members

Agency for Healthcare Research and Quality Ex-Officio
BAINE, William B., MD
Senior Medical Advisor
Center for Outcomes and Evidence
Agency for Healthcare Research and Quality

National Institute of Health Ex-Officio
HENDERSON, David, MD
Deputy Director for Clinical Care
National Institute of Health

Health Resources and Services Administration Ex-Officio
JAY, Lorine J., MPH, RN, CPHQ
Regional Coordinator

Food and Drug Administration Ex-Officio
MURPHEY, Sheila A., MD
Chief, Infection Control Devices Branch
Division of Anesthesiology, General Hospital Infection Control and Dental Devices
Center for Devices and Radiology Health
Food and Drug Administration

Center for Medicare & Medicaid Services (CMS) Ex-Officio
MILLER, Jeannie RN, MPH
Deputy Director, Office of Clinical Standards and Quality/ Clinical Standards Group

Department of Veterans Affairs (VA)
ROSELLE, Gary A., MD
National Program Director, Infectious Diseases
VA Central Office
Cincinnati VA Medical Center

Liaisons

Association of Professionals of Infection Control and Epidemiology, Inc.
BJERKE, Nancy BSN, RN, MPH, CIC

Council of State and Territorial Epidemiologists
KAINER, Marion MD, MPH
Medical Epidemiologist/Infections Diseases Physician Director, Hospital Infections and Antimicrobial Resistance Program, Tennessee Department of Health
Infection Control Consultant
Infection Control Associates

American Health Care Association
FITZLER, Sandra L., RN
Senior Director of Clinical Services
American Health Care Association

American College of Occupational and Environmental Medicine
RUSSI, Mark, MD, MPH
American College of Occupational and Environmental Medicine

Advisory Council for the Elimination of Tuberculosis STRICOF, Rachel L., MPH
New York State Department of Health

American Hospital Association
SCHULMAN, Roslyne, MHA, MBA
Senior Associate Director, Policy Development

Association of periOperative Registered Nurses
BLANCHARD, Joan C., RN, BSN, MSS, CNOR, CIC
Association of periOperative Registered Nurses

Society for Healthcare Epidemiology of America
MARAGAKIS, Lisa, MD
Assistant Professor of Medicine
Johns Hopkins Medical Institutions

Joint Commission on Accreditation of Healthcare Organizations
WISE, Robert A., MD
Division of Standards & Survey Methods
Joint Commission on Accreditation of Healthcare Organizations

Consumers Union
Senior Policy Analyst on
MCGIFFERT, Lisa
Health Issues, Project Director
Stop Hospital Infections Organization

Acknowledgement

HICPAC thanks the following members who served on the HICPAC CAUTI Guideline subcommittee during the guideline development process: Russell N. Olmsted, MPH, Yvette S. McCarter, PhD, Barbara M. Soule, RN, MPA, CIC, and Nalini Singh, MD, MPH.

HICPAC thanks the following outside experts for reviewing a draft of this guideline: Edward S. Wong, MD, Lindsay E. Nicolle, MD, Anthony J. Schaeffer, MD, and Harriett M. Pitt, RN, MS, CIC. The opinions of the reviewers might not be reflected in all the recommendations contained in this document.

HICPAC would also like to thank the many individuals and organizations who provided valuable feedback on the guideline during the public comment period.

Disclosure of Financial Interests and Relationships

The authors C.V.G., C.A.U., R.K.A., and G.K. report no actual or potential conflicts of interest. D.A.P. is on the Speakers Bureau of Merck, Pfizer, Schering, and Cubist and is a consultant for Dow Pharmaceuticals, DaVita, and Vasonova. C.A.U. and R.K.A. received funding from the CDC to support the guideline development process.

Table of Contents

Abbreviations 6
I. Executive Summary 8
II. Summary of Recommendations 10
III. Implementation and Audit 18
IV. Recommendations for Further Research 20
V. Background 22
VI. Scope and Purpose 25
VII. Methods 26
VIII. Evidence Review 34
References 49

Abbreviations

ADL	Activities of daily living
APACHE II	Acute Physiology and Chronic Health Evaluation II
ASA	American Society of Anesthesiologists
ASB	Asymptomatic bacteriuria
BUN	Blood urea nitrogen
CAUTI	Catheter-associated urinary tract infection
CDC	Centers for Disease Control and Prevention
CFU	Colony-forming units
CI	Confidence interval
CIC	Clean intermittent catheterization
CICU	Coronary intensive care unit
COPD	Chronic obstructive pulmonary disease
ED	Emergency department
F/U	Follow-up
GRADE	Grading of Recommendations Assessment, Development, and Evaluation system
Hb	Hemoglobin concentration
HICPAC	Healthcare Infection Control Practices Advisory Committee
H/O	History of
HPF	High power field
HR	Hazard ratio
ICU	Intensive care unit
IDR	Incidence-density ratio
LOS	Length of stay
MDR	Multi-drug resistant
MICU	Medical intensive care unit
NHSN	National Healthcare Safety Network
NIH	National Institutes of Health
NS	Not significant
OBS	Observational controlled study
OR	Odds ratio
P	P value
PACU	Post-anesthesia care unit
PVC	Polyvinyl chloride

RCT	Randomized controlled trial
RD	Risk difference
RH	Relative hazard
RR	Relative risk
SAPS II	Simplified Acute Physiology Score II
SICU	Surgical intensive care unit
SR	Systematic review
SUTI	Symptomatic urinary tract infection
TMP/SMX	Trimethoprim/sulfamethoxazole
TURP	Transurethral resection of prostate
UTI	Urinary tract infection
VAS	Visual analog scale
WMD	Weighted mean difference

I. Executive Summary

This guideline updates and expands the original Centers for Disease Control and Prevention (CDC) Guideline for Prevention of Catheter-associated Urinary Tract Infections (CAUTI) published in 1981. Several developments necessitated revision of the 1981 guideline, including new research and technological advancements for preventing CAUTI, increasing need to address patients in non-acute care settings and patients requiring long-term urinary catheterization, and greater emphasis on prevention initiatives as well as better defined goals and metrics for outcomes and process measures. In addition to updating the previous guideline, this revised guideline reviews the available evidence on CAUTI prevention for patients requiring chronic indwelling catheters and individuals who can be managed with alternative methods of urinary drainage (e.g., intermittent catheterization). The revised guideline also includes specific recommendations for implementation, performance measurement, and surveillance. Although the general principles of CAUTI prevention have not changed from the previous version, the revised guideline provides clarification and more specific guidance based on a defined, systematic review of the literature through July 2007. For areas where knowledge gaps exist, recommendations for further research are listed. Finally, the revised guideline outlines high-priority recommendations for CAUTI prevention in order to offer guidance for implementation.

This document is intended for use by infection prevention staff, healthcare epidemiologists, healthcare administrators, nurses, other healthcare providers, and persons responsible for developing, implementing, and evaluating infection prevention and control programs for healthcare settings across the continuum of care. The guideline can also be used as a resource for societies or organizations that wish to develop more detailed implementation guidance for prevention of CAUTI.

Our goal was to develop a guideline based on a targeted systematic review of the best available evidence, with explicit links between the evidence and recommendations. To accomplish this, we used an adapted GRADE system approach for evaluating quality of evidence and determining strength of recommendations. The methodology, structure, and components of this guideline are approved by HICPAC and will be used for subsequent guidelines issued by HICPAC. A more detailed description of our approach is available in the Methods section.

To evaluate the evidence on preventing CAUTI, we examined data addressing three key questions and related subquestions:

1. Who should receive urinary catheters?
    A. When is urinary catheterization necessary?
    B. What are the risk factors for CAUTI?
    C. What populations are at highest risk of mortality related to urinary catheters?
2. For those who may require urinary catheters, what are the best practices? Specifically, what are the risks and benefits associated with:
    A. Different approaches to catheterization?
    B. Different catheters or collecting systems?
    C. Different catheter management techniques?
    D. Different systems interventions (i.e., quality improvement programs)?
3. What are the best practices for preventing CAUTI associated with obstructed urinary catheters?

Evidence addressing the key questions was used to formulate recommendations, and explicit links between the evidence and recommendations are available in the Evidence Review in the body of the guideline and Evidence Tables and GRADE Tables in the Appendices. **It is important to note that Category I recommendations are all considered strong recommendations and should be equally implemented;** it is only the *quality* of the evidence underlying the recommendation that distinguishes between levels A and B. Category IC recommendations are required by state or federal regulation and may have any level of supporting evidence.

The categorization scheme used in this guideline is presented in Table 1 in the Summary of Recommendations and described further in the Methods section.

The Summary of Recommendations is organized as follows: 1) recommendations for who should receive indwelling urinary catheters (or, for certain populations, alternatives to indwelling catheters); 2) recommendations for catheter insertion; 3) recommendations for catheter maintenance; 4) quality improvement programs to achieve appropriate placement, care, and removal of catheters; 5) administrative infrastructure required; and 6) surveillance strategies.

The Implementation and Audit section includes a prioritization of recommendations (i.e., high-priority recommendations that are essential for every healthcare facility), organized by modules, in order to provide facilities more guidance on implementation of these guidelines. A list of recommended performance measures that can potentially be used for internal reporting purposes is also included.

Areas in need of further research identified during the evidence review are outlined in the Recommendations for Further Research. This section includes guidance for specific methodological approaches that should be used in future studies.

Readers who wish to examine the primary evidence underlying the recommendations are referred to the Evidence Review in the body of the guideline, and the Evidence Tables and GRADE Tables in the Appendices. The Evidence Review includes narrative summaries of the data presented in the Evidence Tables and GRADE Tables. The Evidence Tables include all study-level data used in the guideline, and the GRADE Tables assess the overall quality of evidence for each question. The Appendices also contain a clearly delineated search strategy that will be used for periodic updates to ensure that the guideline remains a timely resource as new information becomes available.

II. Summary of Recommendations

Table 1. Modified HICPAC Categorization Scheme* for Recommendations	
Category IA	A strong recommendation supported by high to moderate quality† evidence suggesting net clinical benefits or harms
Category IB	A strong recommendation supported by low quality evidence suggesting net clinical benefits or harms or an accepted practice (e.g., aseptic technique) supported by low to very low quality evidence
Category IC	A strong recommendation required by state or federal regulation.
Category II	A weak recommendation supported by any quality evidence suggesting a trade off between clinical benefits and harms
No recommendation/ unresolved issue	Unresolved issue for which there is low to very low quality evidence with uncertain trade offs between benefits and harms

* Please refer to Methods (p.32) for implications of Category designations
†Please refer to Methods (p. 29-30) for process used to grade quality of evidence

I. Appropriate Urinary Catheter Use

A. Insert catheters only for appropriate indications (see Table 2 for guidance), and leave in place only as long as needed. **(Category IB)** (Key Questions 1B and 2C)

1. Minimize urinary catheter use and duration of use in all patients, particularly those at higher risk for CAUTI or mortality from catheterization such as women, the elderly, and patients with impaired immunity.**(Category IB)** (Key Questions 1B and 1C)

2. Avoid use of urinary catheters in patients and nursing home residents for management of incontinence. **(Category IB)** (Key Question 1A)

    a. Further research is needed on periodic (e.g., nighttime) use of external catheters (e.g., condom catheters) in incontinent patients or residents and the use of catheters to prevent skin breakdown. **(No recommendation/unresolved issue)** (Key Question 1A)

3. Use urinary catheters in operative patients only as necessary, rather than routinely. **(Category IB)** (Key Question 1A)

4. For operative patients who have an indication for an indwelling catheter, remove the catheter as soon as possible postoperatively, preferably within 24 hours, unless there are appropriate indications for continued use. **(Category IB)** (Key Questions 2A and 2C)

Table 2. **A. Examples of Appropriate Indications for Indwelling Urethral Catheter Use** [1-4]
Patient has acute urinary retention or bladder outlet obstruction
Need for accurate measurements of urinary output in critically ill patients
Perioperative use for selected surgical procedures: • Patients undergoing urologic surgery or other surgery on contiguous structures of the genitourinary tract • Anticipated prolonged duration of surgery (catheters inserted for this reason should be removed in PACU) • Patients anticipated to receive large-volume infusions or diuretics during surgery • Need for intraoperative monitoring of urinary output
To assist in healing of open sacral or perineal wounds in incontinent patients
Patient requires prolonged immobilization (e.g., potentially unstable thoracic or lumbar spine, multiple traumatic injuries such as pelvic fractures)
To improve comfort for end of life care if needed
B. Examples of *Inappropriate* Uses of Indwelling Catheters
As a substitute for nursing care of the patient or resident with incontinence
As a means of obtaining urine for culture or other diagnostic tests when the patient can voluntarily void
For prolonged postoperative duration without appropriate indications (e.g., structural repair of urethra or contiguous structures, prolonged effect of epidural anaesthesia, etc.)

Note: These indications are based primarily on expert consensus.

B. Consider using alternatives to indwelling urethral catheterization in selected patients when appropriate.

1. Consider using external catheters as an alternative to indwelling urethral catheters in cooperative male patients without urinary retention or bladder outlet obstruction. **(Category II)** (Key Question 2A)

2. Consider alternatives to chronic indwelling catheters, such as intermittent catheterization, in spinal cord injury patients. **(Category II)** (Key Question 1A)

3. Intermittent catheterization is preferable to indwelling urethral or suprapubic catheters in patients with bladder emptying dysfunction. **(Category II)** (Key Question 2A)

4. Consider intermittent catheterization in children with myelomeningocele and neurogenic bladder to reduce the risk of urinary tract deterioration. **(Category II)** (Key Question 1A)

5. Further research is needed on the benefit of using a urethral stent as an alternative to an indwelling catheter in selected patients with bladder outlet obstruction. **(No recommendation/unresolved issue)** (Key Question 1A)

6. Further research is needed on the risks and benefits of suprapubic catheters as an alternative to indwelling urethral catheters in selected patients requiring short- or long-term catheterization, particularly with respect to complications related to catheter insertion or the catheter site. **(No recommendation/unresolved issue)** (Key Question 2A)

II. Proper Techniques for Urinary Catheter Insertion

A. Perform hand hygiene immediately before and after insertion or any manipulation of the catheter device or site. **(Category IB)** (Key Question 2D)

B. Ensure that only properly trained persons (e.g., hospital personnel, family members, or patients themselves) who know the correct technique of aseptic catheter insertion and maintenance are given this responsibility. **(Category IB)** (Key Question 1B)

C. In the acute care hospital setting, insert urinary catheters using aseptic technique and sterile equipment. **(Category IB)**

    1. Use sterile gloves, drape, sponges, an appropriate antiseptic or sterile solution for periurethral cleaning, and a single-use packet of lubricant jelly for insertion. **(Category IB)**

    2. Routine use of antiseptic lubricants is not necessary. **(Category II)** (Key Question 2C)

    3. Further research is needed on the use of antiseptic solutions vs. sterile water or saline for periurethral cleaning prior to catheter insertion. **(No recommendation/unresolved issue)** (Key Question 2C)

D. In the non-acute care setting, clean (i.e., non-sterile) technique for intermittent catheterization is an acceptable and more practical alternative to sterile technique for patients requiring chronic intermittent catheterization. **(Category IA)** (Key Question 2A)

    1. Further research is needed on optimal cleaning and storage methods for catheters used for clean intermittent catheterization. **(No recommendation/unresolved issue)** (Key Question 2C)

E. Properly secure indwelling catheters after insertion to prevent movement and urethral traction. **(Category IB)**

F. Unless otherwise clinically indicated, consider using the smallest bore catheter possible, consistent with good drainage, to minimize bladder neck and urethral trauma. **(Category II)**

G. If intermittent catheterization is used, perform it at regular intervals to prevent bladder overdistension. **(Category IB)** (Key Question 2A)

H. Consider using a portable ultrasound device to assess urine volume in patients undergoing intermittent catheterization to assess urine volume and reduce unnecessary catheter insertions. **(Category II)** (Key Question 2C)

    1. If ultrasound bladder scanners are used, ensure that indications for use are clearly stated, nursing staff are trained in their use, and equipment is adequately cleaned and disinfected in between patients. **(Category IB)**

III. Proper Techniques for Urinary Catheter Maintenance

A. Following aseptic insertion of the urinary catheter, maintain a closed drainage system **(Category IB)** (Key Question 1B and 2B)

   1. If breaks in aseptic technique, disconnection, or leakage occur, replace the catheter and collecting system using aseptic technique and sterile equipment. **(Category IB)**

   2. Consider using urinary catheter systems with preconnected, sealed catheter-tubing junctions. **(Category II)** (Key Question 2B)

B. Maintain unobstructed urine flow. **(Category IB)** (Key Questions 1B and 2D)

   1. Keep the catheter and collecting tube free from kinking. **(Category IB)**

   2. Keep the collecting bag below the level of the bladder at all times. Do not rest the bag on the floor. **(Category I**B**)**

   3. Empty the collecting bag regularly using a separate, clean collecting container for each patient; avoid splashing, and prevent contact of the drainage spigot with the nonsterile collecting container. **(Category IB)**

C. Use Standard Precautions, including the use of gloves and gown as appropriate, during any manipulation of the catheter or collecting system. **(Category IB)**

D. Complex urinary drainage systems (utilizing mechanisms for reducing bacterial entry such as antiseptic-release cartridges in the drain port) are not necessary for routine use. **(Category II)** (Key Question 2B)

E. Changing indwelling catheters or drainage bags at routine, fixed intervals is not recommended. Rather, it is suggested to change catheters and drainage bags based on clinical indications such as infection, obstruction, or when the closed system is compromised. **(Category II)** (Key Question 2C)

F. Unless clinical indications exist (e.g., in patients with bacteriuria upon catheter removal post urologic surgery), do not use systemic antimicrobials routinely to prevent CAUTI in patients requiring either short or long-term catheterization. **(Category IB)** (Key Question 2C)

   1. Further research is needed on the use of urinary antiseptics (e.g., methenamine) to prevent UTI in patients requiring short-term catheterization. **(No recommendation/unresolved issue)** (Key Question 2C)

G. Do not clean the periurethral area with antiseptics to prevent CAUTI while the catheter is in place. Routine hygiene (e.g., cleansing of the meatal surface during daily bathing or showering) is appropriate. **(Category IB)** (Key Question 2C)

H. Unless obstruction is anticipated (e.g., as might occur with bleeding after prostatic or bladder surgery) bladder irrigation is not recommended. **(Category II)** (Key Question 2C)

1. If obstruction is anticipated, closed continuous irrigation is suggested to prevent obstruction. **(Category II)**

I. Routine irrigation of the bladder with antimicrobials is not recommended. **(Category II)** (Key Question 2C)

J. Routine instillation of antiseptic or antimicrobial solutions into urinary drainage bags is not recommended. **(Category II)** (Key Question 2C)

K. Clamping indwelling catheters prior to removal is not necessary. **(Category II)** (Key Question 2C)

L. Further research is needed on the use of bacterial interference (i.e., bladder inoculation with a nonpathogenic bacterial strain) to prevent UTI in patients requiring chronic urinary catheterization. **(No recommendation/unresolved issue)** (Key Question 2C)

Catheter Materials

M. If the CAUTI rate is not decreasing after implementing a comprehensive strategy to reduce rates of CAUTI, consider using antimicrobial/antiseptic-impregnated catheters. The comprehensive strategy should include, at a minimum, the high priority recommendations for urinary catheter use, aseptic insertion, and maintenance (see Section III. Implementation and Audit). **(Category IB)** (Key Question 2B)

1. Further research is needed on the effect of antimicrobial/antiseptic-impregnated catheters in reducing the risk of symptomatic UTI, their inclusion among the primary interventions, and the patient populations most likely to benefit from these catheters. **(No recommendation/unresolved issue)** (Key Question 2B)

N. Hydrophilic catheters might be preferable to standard catheters for patients requiring intermittent catheterization. **(Category II)** (Key Question 2B)

O. Silicone might be preferable to other catheter materials to reduce the risk of encrustation in long-term catheterized patients who have frequent obstruction. **(Category II)** (Key Question 3)

P. Further research is needed to clarify the benefit of catheter valves in reducing the risk of CAUTI and other urinary complications. **(No recommendation/unresolved issue)** (Key Question 2B)

Management of Obstruction

Q. If obstruction occurs and it is likely that the catheter material is contributing to obstruction, change the catheter. **(Category IB)**

R. Further research is needed on the benefit of irrigating the catheter with acidifying solutions or use of oral urease inhibitors in long-term catheterized patients who have frequent catheter obstruction. **(No recommendation/unresolved issue)** (Key Question 3)

S. Further research is needed on the use of a portable ultrasound device to evaluate for obstruction in patients with indwelling catheters and low urine output. **(No recommendation/unresolved issue)** (Key Question 2C)

T. Further research is needed on the use of methenamine to prevent encrustation in patients requiring chronic indwelling catheters who are at high risk for obstruction. **(No recommendation/unresolved issue)** (Key Question 2C)

Specimen Collection

U. Obtain urine samples aseptically. **(Category IB)**

   1. If a small volume of fresh urine is needed for examination (i.e., urinalysis or culture), aspirate the urine from the needleless sampling port with a sterile syringe/cannula adapter after cleansing the port with a disinfectant. **(Category IB)**

   2. Obtain large volumes of urine for special analyses (not culture) aseptically from the drainage bag. **(Category IB)**

Spatial Separation of Catheterized Patients

V. Further research is needed on the benefit of spatial separation of patients with urinary catheters to prevent transmission of pathogens colonizing urinary drainage systems. **(No recommendation/unresolved issue)** (Key Question 2D)

IV. Quality Improvement Programs

A. Implement quality improvement (QI) programs or strategies to enhance appropriate use of indwelling catheters and to reduce the risk of CAUTI based on a facility risk assessment. **(Category IB)** (Key Question 2D)

   The purposes of QI programs should be: 1) to assure appropriate utilization of catheters 2) to identify and remove catheters that are no longer needed (e.g., daily review of their continued need) and 3) to ensure adherence to hand hygiene and proper care of catheters. Examples of programs that have been demonstrated to be effective include:

   1. A system of alerts or reminders to identify all patients with urinary catheters and assess the need for continued catheterization

   2. Guidelines and protocols for nurse-directed removal of unnecessary urinary catheters

   3. Education and performance feedback regarding appropriate use, hand hygiene, and catheter care

   4. Guidelines and algorithms for appropriate peri-operative catheter management, such as:

a. Procedure-specific guidelines for catheter placement and postoperative catheter removal

b. Protocols for management of postoperative urinary retention, such as nurse-directed use of intermittent catheterization and use of bladder ultrasound scanners

V. Administrative Infrastructure

A. Provision of guidelines

1. Provide and implement evidence-based guidelines that address catheter use, insertion, and maintenance. **(Category IB)**

   a. Consider monitoring adherence to facility-based criteria for acceptable indications for indwelling urinary catheter use. **(Category II)**

B. Education and Training

1. Ensure that healthcare personnel and others who take care of catheters are given periodic in-service training regarding techniques and procedures for urinary catheter insertion, maintenance, and removal. Provide education about CAUTI, other complications of urinary catheterization, and alternatives to indwelling catheters. **(Category IB)**

2. When feasible, consider providing performance feedback to these personnel on what proportion of catheters they have placed meet facility-based criteria and other aspects related to catheter care and maintenance. **(Category II)**

C. Supplies

1. Ensure that supplies necessary for aseptic technique for catheter insertion are readily available. **(Category IB)**

D. System of documentation

1. Consider implementing a system for documenting the following in the patient record: indications for catheter insertion, date and time of catheter insertion, individual who inserted catheter, and date and time of catheter removal. **(Category II)**

   a. Ensuring that documentation is accessible in the patient record and recorded in a standard format for data collection and quality improvement purposes is suggested. Electronic documentation that is searchable is preferable. **(Category II)**

E. Surveillance resources

1. If surveillance for CAUTI is performed, ensure that there are sufficient trained personnel and technology resources to support surveillance for urinary catheter use and outcomes. **(Category IB)**

VI. Surveillance

A. Consider surveillance for CAUTI when indicated by facility-based risk assessment. **(Category II)**

   1. Identify the patient groups or units on which to conduct surveillance based on frequency of catheter use and potential risk of CAUTI.

B. Use standardized methodology for performing CAUTI surveillance. **(Category IB)**

   1. Examples of metrics that should be used for CAUTI surveillance include:

      a. Number of CAUTI per 1000 catheter-days

      b. Number of bloodstream infections secondary to CAUTI per 1000 catheter-days

      c. Catheter utilization ratio: (urinary catheter days/patient days) x 100

   2. Use CDC/NHSN criteria for identifying patients who have symptomatic UTI (SUTI) (numerator data) (see NHSN Patient Safety Manual: http://www.cdc.gov/nhsn/library.html).

   3. For more information on metrics, please see the U.S. Department of Health & Human Services (HHS) Action Plan to Prevent Healthcare-Associated Infections: http://www.hhs.gov/ophs/initiatives/hai/infection.html.

C. Routine screening of catheterized patients for asymptomatic bacteriuria (ASB) is not recommended. **(Category II)** (Key Question 2D)

D. When performing surveillance for CAUTI, consider providing regular (e.g., quarterly) feedback of unit-specific CAUTI rates to nursing staff and other appropriate clinical care staff. **(Category II)** (Key Question 2D)

III. Implementation and Audit

Prioritization of Recommendations

In this section, the recommendations considered essential for *all* healthcare facilities caring for patients requiring urinary catheterization are organized into modules in order to provide more guidance to facilities on implementation of these guidelines. The high-priority recommendations were chosen by a consensus of experts based on strength of recommendation as well as on the likely impact of the strategy in preventing CAUTI. The administrative functions and infrastructure listed above in the summary of recommendations are necessary to accomplish the high priority recommendations and are therefore critical to the success of a prevention program. In addition, quality improvement programs should be implemented as an active approach to accomplishing these recommendations and when process and outcome measure goals are not being met based on internal reporting.

Priority Recommendations for Appropriate Urinary Catheter Use (Module 1)

- Insert catheters only for appropriate indications (see Table 2), and leave in place only as long as needed. **(Category IB)**
    - Avoid use of urinary catheters in patients and nursing home residents for management of incontinence. **(Category IB)**
    - For operative patients who have an indication for an indwelling catheter, remove the catheter as soon as possible postoperatively, preferably within 24 hours, unless there are appropriate indications for continued use. **(Category IB)**

Priority Recommendations for Aseptic Insertion of Urinary Catheters (Module 2)

- Ensure that only properly trained persons (e.g., hospital personnel, family members, or patients themselves) who know the correct technique of aseptic catheter insertion and maintenance are given this responsibility. **(Category IB)**
- In the acute care hospital setting, insert catheters using aseptic technique and sterile equipment. **(Category IB)**

Priority Recommendations for Proper Urinary Catheter Maintenance (Module 3)

- Following aseptic insertion of the urinary catheter, maintain a closed drainage system **(Category IB)**
- Maintain unobstructed urine flow. **(Category IB)**

Performance Measures

A. Internal Reporting. Consider reporting both process and outcome measures to senior administrative, medical, and nursing leadership and clinicians who care for patients at risk for CAUTI. **(Category II)**
    1. Examples of process measures:
        a) Compliance with educational program: Calculate percent of personnel who have proper training:
            - Numerator: number of personnel who insert urinary catheters and who have proper training
            - Denominator: number of personnel who insert urinary catheters
            - Standardization factor: 100 (i.e., multiply by 100 so that measure is expressed as a percentage)

b) Compliance with documentation of catheter insertion and removal dates: Conduct random audits of selected units and calculate compliance rate:
    - Numerator: number of patients on unit with catheters with proper documentation of insertion and removal dates
    - Denominator: number of patients on the unit with a catheter in place at some point during admission
    - Standardization factor: 100 (i.e., multiply by 100 so that measure is expressed as a percentage)

c) Compliance with documentation of indication for catheter placement: Conduct random audits of selected units and calculate compliance rate
    - Numerator: number of patients on unit with catheters with proper documentation of indication
    - Denominator: number of patients on the unit with catheter in place
    - Standardization factor: 100 (i.e., multiply by 100 so that measure is expressed as a percentage)

2. Recommended outcome measures:

a) Rates of CAUTI: Use NHSN definitions (see http://www.cdc.gov/nhsn/library.html). Measurement of rates allows an individual facility to gauge the longitudinal impact of implementation of prevention strategies:
    - Numerator: number of CAUTIs in each location monitored
    - Denominator: total number of urinary catheter-days for all patients that have an indwelling urinary catheter in each location monitored
    - Standardization factor: Multiply by 1000 so that the measure is expressed as cases per 1000 catheter-days

b) Rate of bloodstream infections secondary to CAUTI: Use NHSN definitions for laboratory-confirmed bloodstream infection, available at http://www.cdc.gov/nhsn/library.html.
    - Numerator: number of episodes of bloodstream infections secondary to CAUTI
    - Denominator: total number of urinary catheter-days for all patients that have an indwelling urinary catheter in each location monitored
    - Standardization factor: Multiply by 1000 so that the measure is expressed as cases per 1000 catheter-days

B. External Reporting. Current NHSN definitions for CAUTI were developed for monitoring of rates within a facility; however, reporting of CAUTI rates for facility-to-facility comparison might be requested by state requirements and external quality initiatives.

IV. Recommendations for Further Research

Our literature review revealed that many of the studies addressing strategies to prevent CAUTI were not of sufficient quality to allow firm conclusions regarding the benefit of certain interventions. Future studies of CAUTI prevention should:

1) Be primary analytic research (i.e. systematic reviews, meta-analyses, interventional studies, and observational studies [cohort, case-control, analytic cross-sectional studies])
2) Evaluate clinically relevant outcomes (e.g., SUTI, bloodstream infections secondary to CAUTI)
3) Adjust for confounders as needed using multivariable analyses
4) Stratify outcomes by patient populations at risk for CAUTI
5) Ensure adequate statistical power to detect differences

The following is a compilation of recommendations for further research:

1. Catheter materials
    a. Antimicrobial and antiseptic-impregnated catheters
        i. Effect of catheters on reducing the risk of SUTI and other clinically significant outcomes
        ii. Patient populations most likely to benefit
        iii. Incidence of antimicrobial resistance in urinary pathogens
        iv. Role of bacterial biofilms in the pathogenesis of CAUTI
    b. Standard catheters
        i. Optimal materials for reducing the risk of CAUTI and other urethral complications

2. Appropriate urinary catheter use
    a. Incontinent patients
        i. Risks and benefits of periodic (e.g., nighttime) use of external catheters
        ii. Risk of local complications (e.g., skin maceration, phimosis) with the use of external catheters
        iii. Appropriate use of urinary catheters to manage sacral or perineal wounds
    b. Appropriate indications for continued use in postoperative patients and associated risks

3. Antiseptics
    a. Use of antiseptic vs. sterile solutions for periurethral cleaning prior to catheter insertion
    b. Use of antiseptics (e.g., methenamine) to prevent CAUTI

4. Alternatives to indwelling urethral catheters and bag drainage
    a. Risks and benefits of suprapubic catheters as an alternative to chronic indwelling urethral catheters
    b. Use of a urethral stent as an alternative to an indwelling catheter in selected patients with bladder outlet obstruction
    c. Use of catheter valves in reducing the risk of CAUTI and other urinary complications
    d. Other alternative methods of urinary drainage

5. Optimal methods for preventing encrustation in long-term catheterized patients who have frequent obstruction
    a. Optimal catheter materials
    b. Irrigation with acidifying solutions or oral urease inhibitors
    c. Use of methenamine

6. Other prevention measures
    a. Use of portable ultrasound in patients with low-urine output to reduce unnecessary catheter insertions or irrigations (in catheterized patients)
    b. Use of new prevention strategies such as bacterial interference in patients requiring chronic catheterization
    c. Optimal cleaning and storage procedures (e.g., wet vs. dry storage) for catheters used for clean intermittent catheterization

7. Prevention of transmission
    a. Spatial separation of patients with urinary catheters (in the absence of epidemic spread or frequent cross-infection) to prevent transmission of pathogens colonizing urinary drainage systems

V. Background

Urinary tract infections are the most common type of healthcare-associated infection, accounting for more than 30% of infections reported by acute care hospitals.[19] Virtually all healthcare-associated UTIs are caused by instrumentation of the urinary tract. Catheter-associated urinary tract infection (CAUTI) has been associated with increased morbidity, mortality, hospital cost, and length of stay.[6-9] In addition, bacteriuria commonly leads to unnecessary antimicrobial use, and urinary drainage systems are often reservoirs for multidrug-resistant bacteria and a source of transmission to other patients.[10,11]

Definitions

An indwelling urinary catheter is a drainage tube that is inserted into the urinary bladder through the urethra, is left in place, and is connected to a closed collection system. Alternative methods of urinary drainage may be employed in some patients. Intermittent ("in-and-out") catheterization involves brief insertion of a catheter into the bladder through the urethra to drain urine at intervals. An external catheter is a urine containment device that fits over or adheres to the genitalia and is attached to a urinary drainage bag. The most commonly used external catheter is a soft flexible sheath that fits over the penis ("condom" catheter). A suprapubic catheter is surgically inserted into the bladder through an incision above the pubis.

Although UTIs associated with alternative urinary drainage systems are considered device-associated, CAUTI rates reported to the National Healthcare Safety Network (NHSN) only refer to those associated with indwelling urinary catheters. NHSN has recently revised the UTI surveillance definition criteria. Among the changes are removal of the asymptomatic bacteriuria (ASB) criterion and refinement of the criteria for defining symptomatic UTI (SUTI). The time period for follow-up surveillance after catheter removal also has been shortened from 7 days to 48 hours to align with other device-associated infections. The new UTI criteria, which took effect in January 2009, can be found in the NHSN Patient Safety Manual (http://www.cdc.gov/nhsn/library.html).

The limitations and heterogeneity of definitions of CAUTI used in various studies present major challenges in appraising the quality of evidence in the CAUTI literature. Study investigators have used numerous different definitions for CAUTI outcomes, ranging from simple bacteriuria at a range of concentrations to, less commonly, symptomatic infection defined by combinations of bacteriuria and various signs and symptoms. Futhermore, most studies that used CDC/NHSN definitions for CAUTI did not distinguish between SUTI and ASB in their analyses.[30] The heterogeneity of definitions used for CAUTI may reduce the quality of evidence for a given intervention and often precludes meta-analyses.

The clinical significance of ASB in catheterized patients is undefined. Approximately 75% to 90% of patients with ASB do not develop a systemic inflammatory response or other signs or symptoms to suggest infection.[6,31] Monitoring and treatment of ASB is also not an effective prevention measure for SUTI, as most cases of SUTI are not preceded by bacteriuria for more than a day.[25] Treatment of ASB has not been shown to be clinically beneficial and is associated with the selection of antimicrobial-resistant organisms.

Epidemiology

Between 15% and 25% of hospitalized patients may receive short-term indwelling urinary catheters.[12,13] In many cases, catheters are placed for inappropriate indications, and healthcare providers are often unaware that their patients have catheters, leading to prolonged, unnecessary use.[14-16] In acute care hospitals reporting to NHSN in 2006, pooled mean urinary catheter utilization ratios in ICU and non-ICU areas ranged from 0.23-0.91 urinary catheter-days/patient-days.[17] While the numbers of units reporting were small, the highest ratios were in trauma ICUs and the lowest in inpatient medical/surgical wards. The overall prevalence of long-term indwelling urethral catheterization use is unknown. The prevalence of urinary catheter use in residents in long-term care facilities in the United States is on the order of 5%, representing approximately 50,000 residents with catheters at any given time.[18] This number appears to be declining over time, likely because of federally mandated nursing home quality measures. However, the high prevalence of urinary catheters in patients transferred to skilled nursing facilities suggests that acute care hospitals should focus more efforts on removing unnecessary catheters prior to transfer.[18]

Reported rates of UTI among patients with urinary catheters vary substantially. National data from NHSN acute care hospitals in 2006 showed a range of pooled mean CAUTI rates of 3.1-7.5 infections per 1000 catheter-days.[17] The highest rates were in burn ICUs, followed by inpatient medical wards and neurosurgical ICUs, although these sites also had the fewest numbers of locations reporting. The lowest rates were in medical/surgical ICUs.

Although morbidity and mortality from CAUTI is considered to be relatively low compared to other HAIs, the high prevalence of urinary catheter use leads to a large cumulative burden of infections with resulting infectious complications and deaths. An estimate of annual incidence of HAIs and mortality in 2002, based on a broad survey of US hospitals, found that urinary tract infections made up the highest number of infections (> 560,000) compared to other HAIs, and attributable deaths from UTI were estimated to be over 13,000 (mortality rate 2.3%).[19] And while fewer than 5% of bacteriuric cases develop bacteremia,[6] CAUTI is the leading cause of secondary nosocomial bloodstream infections; about 17% of hospital-acquired bacteremias are from a urinary source, with an associated mortality of approximately 10%.[20] In the nursing home setting, bacteremias are most commonly caused by UTIs, the majority of which are catheter-related.[21]

An estimated 17% to 69% of CAUTI may be preventable with recommended infection control measures, which means that up to 380,000 infections and 9000 deaths related to CAUTI per year could be prevented.[22]

Pathogenesis and Microbiology

The source of microorganisms causing CAUTI can be endogenous, typically via meatal, rectal, or vaginal colonization, or exogenous, such as via contaminated hands of healthcare personnel or equipment. Microbial pathogens can enter the urinary tract either by the extraluminal route, via migration along the outside of the catheter in the periurethral mucous sheath, or by the intraluminal route, via movement along the internal lumen of the catheter from a contaminated collection bag or catheter-drainage tube junction. The relative contribution of each route in the pathogenesis of CAUTI is not well known. The marked reduction in risk of bacteriuria with the introduction of the sterile, closed urinary drainage system in the1960's[23] suggests the importance of the intraluminal route. However, even with the closed drainage system,

bacteriuria inevitably occurs over time either via breaks in the sterile system or via the extraluminal route.[24] The daily risk of bacteriuria with catheterization is 3% to 10%,[25,26] approaching 100% after 30 days, which is considered the delineation between short and long-term catheterization.[27]

Formation of biofilms by urinary pathogens on the surface of the catheter and drainage system occurs universally with prolonged duration of catheterization.[28] Over time, the urinary catheter becomes colonized with microorganisms living in a sessile state within the biofilm, rendering them resistant to antimicrobials and host defenses and virtually impossible to eradicate without removing the catheter. The role of bacteria within biofilms in the pathogenesis of CAUTI is unknown and is an area requiring further research.

The most frequent pathogens associated with CAUTI (combining both ASB and SUTI) in hospitals reporting to NHSN between 2006-2007 were *Escherichia coli* (21.4%) and *Candida* spp (21.0%), followed by *Enterococcus* spp (14.9%), *Pseudomonas aeruginosa* (10.0%), *Klebsiella pneumoniae* (7.7%), and *Enterobacter* spp (4.1%). A smaller proportion was caused by other gram-negative bacteria and *Staphylococcus* spp [5].

Antimicrobial resistance among urinary pathogens is an ever increasing problem. About a quarter of *E. coli* isolates and one third of *P. aeruginosa* isolates from CAUTI cases were fluoroquinolone-resistant. Resistance of gram-negative pathogens to other agents, including third-generation cephalosporins and carbapenems, was also substantial [5]. The proportion of organisms that were multidrug-resistant, defined by non-susceptibility to all agents in 4 classes, was 4% of *P. aeruginosa*, 9% of *K. pneumoniae*, and 21% of *Acinetobacter baumannii*. [29]

VI. Scope and Purpose

This guideline updates and expands the original CDC Guideline for Prevention of CAUTI published in 1981. The revised guideline addresses the prevention of CAUTI for patients in need of either short- or long-term (i.e., > 30 days) urinary catheterization in any type of healthcare facility and evaluates evidence for alternative methods of urinary drainage, including intermittent catheterization, external catheters, and suprapubic catheters. The guideline also includes specific recommendations for implementation, performance measurement, and surveillance. Recommendations for further research are also provided to address the knowledge gaps in CAUTI prevention identified during the literature review.

To evaluate the evidence on preventing CAUTI, we examined data addressing three key questions and related subquestions:

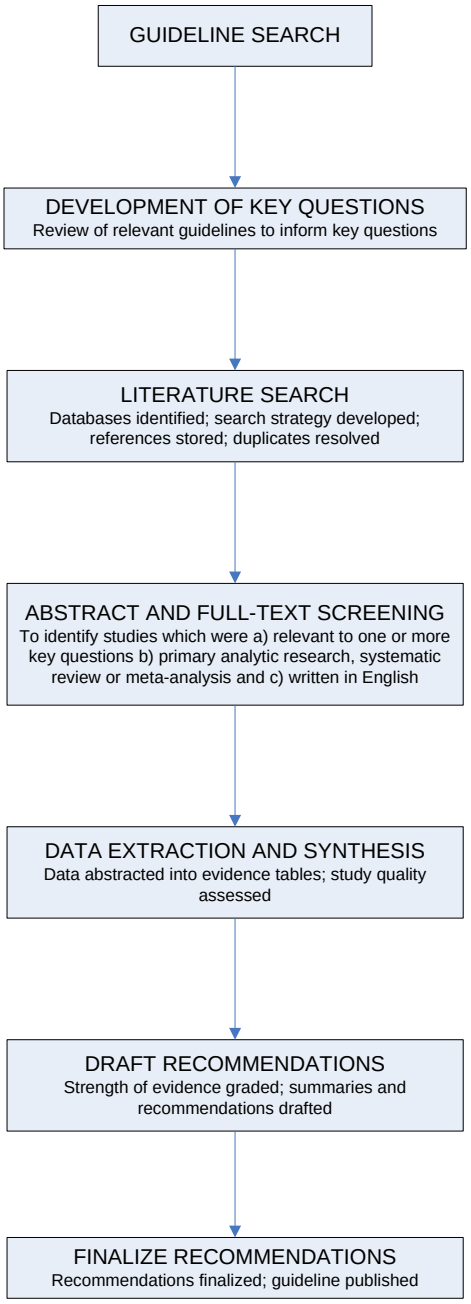
1. Who should receive urinary catheters?
    A. When is urinary catheterization necessary?
    B. What are the risk factors for CAUTI?
    C. What populations are at highest risk of mortality from catheters?
2. For those who may require urinary catheters, what are the best practices? Specifically, what are the risks and benefits associated with:
    A. Different approaches to catheterization?
    B. Different catheters or collecting systems?
    C. Different catheter management techniques?
    D. Different systems interventions (i.e., quality improvement programs)?
3. What are the best practices for preventing UTI associated with obstructed urinary catheters?

This document is intended for use by infection prevention staff, healthcare epidemiologists, healthcare administrators, nurses, other healthcare providers, and persons responsible for developing, implementing, and evaluating infection prevention and control programs for healthcare settings across the continuum of care. The guideline can also be used as a resource for societies or organizations that wish to develop more detailed implementation guidance for prevention of CAUTI.

VII. Methods

This guideline was based on a targeted systematic review of the best available evidence on CAUTI prevention. We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach [32-34] to provide explicit links between the available evidence and the resulting recommendations. Our guideline development process is outlined in *Figure 1.*

Figure 1. The Guideline Development Process



Development of Key Questions

We first conducted an electronic search of the National Guideline Clearinghouse® (Agency for Healthcare Research and Quality), Medline® (National Library of Medicine) using the Ovid® Platform (Ovid Technologies, Wolters Kluwer, New York, NY), the Cochrane® Health Technology Assessment Database (Cochrane Collaboration, Oxford, UK), the NIH Consensus Development Program, and the United States Preventive Services Task Force database for existing national and international guidelines relevant to CAUTI. The strategy used for the guideline search and the search results can be found in Appendix 1A. A preliminary list of key questions was developed from a review of the relevant guidelines identified in the search.[1,35,36] Key questions were finalized after vetting them with a panel of content experts and HICPAC members.

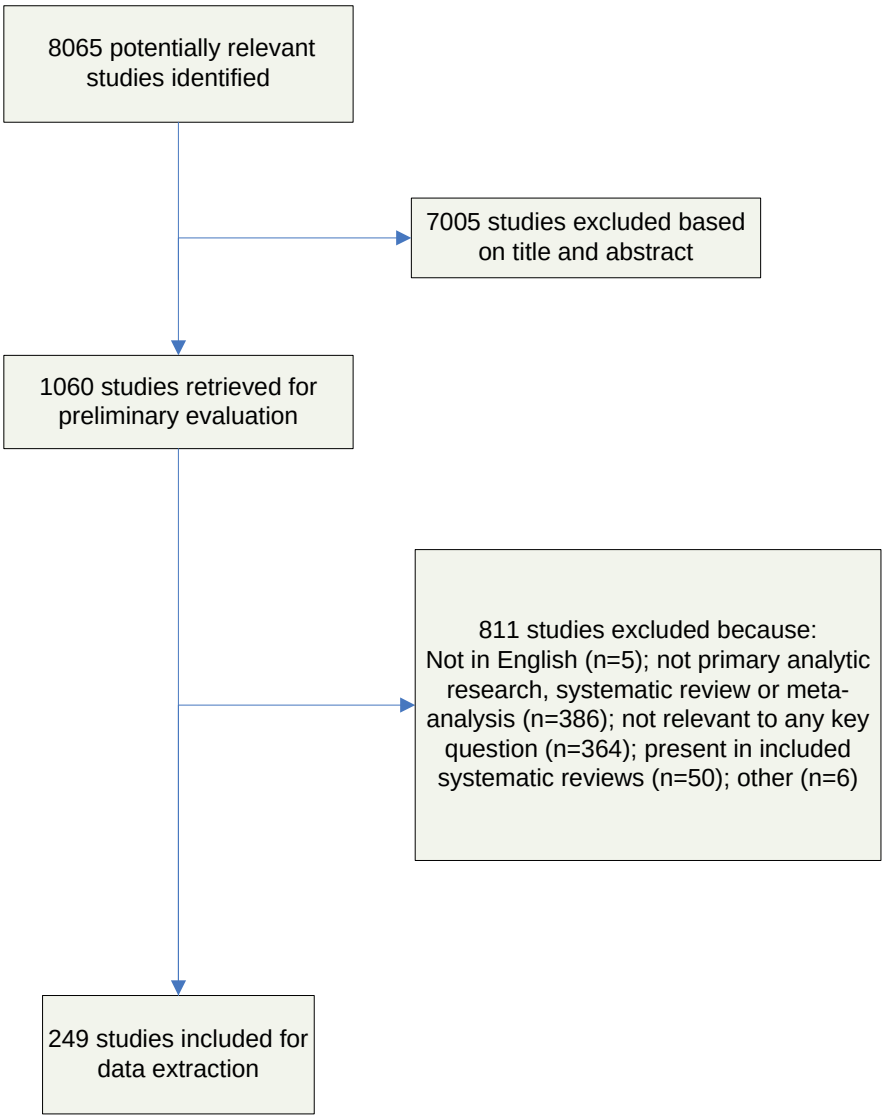
Literature Search

Following the development of the key questions, search terms were developed for identifying literature relevant to the key questions. For the purposes of quality assurance, we compared these terms to those used in relevant seminal studies and guidelines. These search terms were then incorporated into search strategies for the relevant electronic databases. Searches were performed in Medline® (National Library of Medicine) using the Ovid® Platform (Ovid Technologies, Wolters Kluwer, New York, NY), EMBASE® (Elsevier BV, Amsterdam, Netherlands), CINAHL® (Ebsco Publishing, Ipswich, MA) and Cochrane® (Cochrane Collaboration, Oxford, UK) (all databases were searched in July 2007), and the resulting references were imported into a reference manager, where duplicates were resolved. For Cochrane reviews ultimately included in our guideline, we checked for updates in July 2008. The detailed search strategy used for identifying primary literature and the results of the search can be found in Appendix 1B.

Study Selection

Titles and abstracts from references were screened by a single author (C.V.G, R.K.A., or D.A.P.) and the full text articles were retrieved if they were 1) relevant to one or more key questions, 2) primary analytic research, systematic reviews or meta-analyses, and 3) written in English. Likewise, the full-text articles were screened by a single author (C.V.G. or D.A.P.) using the same criteria, and included studies underwent a second review for inclusion by another author (R.K.A.). Disagreements were resolved by the remaining authors. The results of this process are depicted in *Figure 2.*

Figure 2: Results of the Study Selection Process



Data Extraction and Synthesis

Data on the study author, year, design, objective, population, setting, sample size, power, follow-up, and definitions and results of clinically relevant outcomes were extracted into evidence tables (Appendix 2). Three evidence tables were developed, each of which represented one of our key questions. Studies were extracted into the most relevant evidence table. Then, studies were organized by the common themes that emerged within each evidence table. Data were extracted by one author (R.K.A.) and cross-checked by another (C.V.G.). Disagreements were resolved by the remaining authors. Data and analyses were extracted as originally presented in the included studies. Meta-analyses were performed only where their use was deemed critical to a recommendation, and only in circumstances where multiple studies with sufficiently homogenous populations, interventions, and outcomes could be analyzed. Systematic reviews were included in our review. To avoid duplication of data, we excluded primary studies if they were also included in a systematic review captured by our search. The only exception to this was if the primary study also addressed a relevant question that was outside the scope of the included systematic review. Before exclusion, data from the primary studies that we originally captured were abstracted into the evidence tables and reviewed. We also excluded systematic reviews that analyzed primary studies that were fully captured in a more recent systematic review. The only exception to this was if the older systematic review also addressed a relevant question that was outside the scope of the newer systematic review. To ensure that all relevant studies were captured in the search, the bibliography was vetted by a panel of clinical experts.

Grading of Evidence

First, the quality of each study was assessed using scales adapted from existing methodology checklists, and scores were recorded in the evidence tables. Appendix 3 includes the sets of questions we used to assess the quality of each of the major study designs. Next, the quality of the evidence base was assessed using methods adapted from the GRADE Working Group.[32] Briefly, GRADE tables were developed for each of the interventions or questions addressed within the evidence tables. Included in the GRADE tables were the intervention of interest, any outcomes listed in the evidence tables that were judged to be clinically important, the quantity and type of evidence for each outcome, the relevant findings, and the GRADE of evidence for each outcome, as well as an overall GRADE of the evidence base for the given intervention or question. The initial GRADE of evidence for each outcome was deemed high if the evidence base included a randomized controlled trial (RCT) or a systematic review of RCTs, low if the evidence base included only observational studies, or very low if the evidence base consisted only of uncontrolled studies. The initial GRADE could then be modified by eight criteria.[34] Criteria which could decrease the GRADE of an evidence base included quality, consistency, directness, precision, and publication bias. Criteria that could increase the GRADE included a large magnitude of effect, a dose-response gradient, or inclusion of unmeasured confounders that would increase the magnitude of effect (Table 3). GRADE definitions are as follows:

1. High - further research is very unlikely to change confidence in the estimate of effect
2. Moderate - further research is likely to affect confidence in the estimate of effect and may change the estimate
3. Low - further research is very likely to affect confidence in the estimate of effect and is likely to change the estimate
4. Very low - any estimate of effect is very uncertain

After determining the GRADE of the evidence base for each outcome of a given intervention or question, we calculated the overall GRADE of the evidence base for that intervention or question. The overall GRADE was based on the lowest GRADE for the outcomes deemed critical to making a recommendation.

Table 3. Rating the Quality of Evidence Using the GRADE Approach

Type of Evidence	Initial Grade	Criteria to Decrease Grade	Criteria to Increase Grade	Overall Quality Grade
RCT	High	Quality Serious (-1 grade) or very serious (-2 grades) limitation to study quality Consistency Important inconsistency (-1 grade) Directness Some (-1 grade) or major (-2 grades) uncertainty about directness Precision Imprecise or sparse data (-1 grade) Publication bias High risk of bias (-1 grade)	Strong association Strong (+1 grade) or very strong evidence of association (+2 grades) Dose-response Evidence of a dose-response gradient (+1 grade) Unmeasured Confounders Inclusion of unmeasured confounders increases the magnitude of effect (+1 grade)	High Moderate Low Very low
Observational study	Low			
Any other evidence (e.g., expert opinion)	Very low			

Formulating Recommendations

Narrative evidence summaries were then drafted by the working group using the evidence and GRADE tables. One summary was written for each theme that emerged under each key question. The working group then used the narrative evidence summaries to develop guideline recommendations. Factors determining the strength of a recommendation included 1) the values and preferences used to determine which outcomes were "critical," 2) the harms and benefits that result from weighing the "critical" outcomes, and 3) the overall GRADE of the evidence base for the given intervention or question (Table 4).[33] If weighing the "critical outcomes" for a given intervention or question resulted in a "net benefit" or a "net harm," then a "Category I Recommendation" was formulated to strongly recommend for or against the given intervention respectively. If weighing the "critical outcomes" for a given intervention or question resulted in a "trade off" between benefits and harms, then a "Category II Recommendation" was formulated to recommend that providers or institutions consider the intervention when deemed appropriate. If weighing the "critical outcomes" for a given intervention or question resulted in

an "uncertain trade off" between benefits and harms, then a "No Recommendation" was formulated to reflect this uncertainty.

Table 4. Formulating Recommendations		
HICPAC Recommendation	**Weighing Benefits and Harms for Critical Outcomes**	**Quality of Evidence**
STRONG (I)	Interventions with net benefits or net harms	IA – High to Moderate IB – Low or Very Low (Accepted Practice) IC – High to Very Low (Regulatory)
WEAK (II)	Inteventions with trade offs between benefits and harms	High to Very Low
No recommendation/ unresolved issue	Uncertain trade offs between benefits and harms	Low to Very Low

For Category I recommendations, levels A and B represent the quality of the evidence underlying the recommendation, with A representing high to moderate quality evidence and B representing low quality evidence or, in the case of an established standard (e.g., aseptic technique, education and training), very low quality to no evidence based on our literature review. For IB recommendations, although there may be low to very low quality or even no available evidence directly supporting the benefits of the intervention, the theoretical benefits are clear, and the theoretical risks are marginal. Level C represents practices required by state or federal regulation, regardless of the quality of evidence. It is important to note that the strength of a Category IA recommendation is equivalent to that of a Category IB or IC recommendation; it is only the quality of the evidence underlying the IA recommendation that makes it different from a IB.

In some instances, multiple recommendations emerged from a single narrative evidence summary. The new HICPAC categorization scheme for recommendations is provided in Table 1, which is reproduced below.

Table 1. Modified HICPAC Categorization Scheme for Recommendations	
Category IA	A strong recommendation supported by high to moderate quality evidence suggesting net clinical benefits or harms
Category IB	A strong recommendation supported by low quality evidence suggesting net clinical benefits or harms or an accepted practice (e.g., aseptic technique) supported by low to very low quality evidence
Category IC	A strong recommendation required by state or federal regulation.
Category II	A weak recommendation supported by any quality evidence suggesting a trade off between clinical benefits and harms
No recommendation/ unresolved issue	Unresolved issue for which there is low to very low quality evidence with uncertain trade offs between benefits and harms

Category I recommendations are defined as strong recommendations with the following implications:

1. For patients: Most people in the patient's situation would want the recommended course of action and only a small proportion would not; request discussion if the intervention is not offered.
2. For clinicians: Most patients should receive the recommended course of action.
3. For policymakers: The recommendation may be adopted as a policy.

Category II recommendations are defined as weak recommendations with the following implications:

1. For patients: Most people in the patient's situation would want the recommended course of action, but many would not.
2. For clinicians: Different choices will be appropriate for different patients, and clinicians must help each patient to arrive at a management decision consistent with her or his values and preferences.
3. For policymakers: Policy making will require substantial debate and involvement of many stakeholders.

It should be noted that Category II recommendations are discretionary for the individual institution and are not intended to be enforced.

The wording of each recommendation was carefully selected to reflect the recommendation's strength. In most cases, we used the active voice when writing Category I recommendations - the strong recommendations. Phrases like "do" or "do not" and verbs without auxiliaries or conditionals were used to convey certainty. We used a more passive voice when writing Category II recommendations - the weak recommendations. Words like "consider" and phrases like "is preferable," "is suggested," "is not suggested," or "is not recommended" were chosen to reflect the lesser certainty of the Category II recommendations. Rather than a simple statement of fact, each recommendation is actionable, describing precisely a proposed action to take.

The category "No recommendation/unresolved issue" was most commonly applied to situations where either 1) the overall quality of the evidence base for a given intervention was low to very low and there was no consensus on the benefit of the intervention or 2) there was no published evidence on outcomes deemed critical to weighing the risks and benefits of a given intervention. If the latter was the case, those critical outcomes will be noted at the end of the relevant evidence summary.

Our evidence-based recommendations were cross-checked with those from guidelines identified in our original systematic search. Recommendations from previous guidelines for topics not directly addressed by our systematic review of the evidence were included in our "Summary of Recommendations" if they were deemed critical to the target users of this guideline. Unlike recommendations informed by our literature search, these recommendations are not linked to a key question. These recommendations were agreed upon by expert consensus and are designated either IB if they represent a strong recommendation based on accepted practices (e.g., aseptic technique) or II if they are a suggestion based on a probable net benefit despite limited evidence.
All recommendations were approved by HICPAC. Recommendations focused only on efficacy, effectiveness, and safety. The optimal use of these guidelines should include a consideration of the costs relevant to the local setting of guideline users.

Reviewing and Finalizing the Guideline

After a draft of the tables, narrative summaries, and recommendations was completed, the working group shared the draft with the expert panel for in-depth review. While the expert panel was reviewing this draft, the working group completed the remaining sections of the guideline, including the executive summary, background, scope and purpose, methods, summary of recommendations, and recommendations for guideline implementation, audit, and further research. The working group then made revisions to the draft based on feedback from members of the expert panel and presented the entire draft guideline to HICPAC for review. The guideline was then posted on the Federal Register for public comment. After a period of public comment, the guideline was revised accordingly, and the changes were reviewed and voted on by HICPAC. The final guideline was cleared internally by CDC and published and posted on the HICPAC website.

Updating the Guideline

Future revisions to this guideline will be dictated by new research and technological advancements for preventing CAUTI and will occur at the request of HICPAC.

VIII. Evidence Review

Q1. Who should receive urinary catheters?

To answer this question, we focused on three subquestions: A) When is urinary catheterization necessary? B) What are the risk factors for CAUTI? and C) What populations are at highest risk of mortality from urinary catheters?

Q1A. When is urinary catheterization necessary?

The available data examined five main populations. In all populations, we considered CAUTI outcomes as well as other outcomes we deemed critical to weighing the risks and benefits of catheterization. The evidence for this question consists of 1 systematic review,[37] 9 RCTs,[38-46] and 12 observational studies.[47-58] The findings of the evidence review and the grades for all important outcomes are shown in Evidence Review Table 1A.

For *operative patients*, low-quality evidence suggested a benefit of avoiding urinary catheterization.[37-44,47-49] This was based on a decreased risk of bacteriuria/unspecified UTI, no effect on bladder injury, and increased risk of urinary retention in patients without catheters. Urinary retention in patients without catheters was specifically seen following urogenital surgeries. The most common surgeries studied were urogenital, gynecological, laparoscopic, and orthopedic surgeries. Our search did not reveal data on the impact of catheterization on peri-operative hemodynamic management.

For *incontinent patients*, low-quality evidence suggested a benefit of avoiding urinary catheterization.[45,50-52] This was based on a decreased risk of both SUTI and bacteriuria/unspecified UTI in male nursing home residents without urinary catheters compared to those with continuous condom catheters. We found no difference in the risk of UTI between having a condom catheter only at night and having no catheter. Our search did not reveal data on the impact of catheterization on skin breakdown.

For *patients with bladder outlet obstruction*, very low-quality evidence suggested a benefit of a urethral stent over an indwelling catheter.[53] This was based on a reduced risk of bacteriuria in those receiving a urethral stent. Our search did not reveal data on the impact of catheterization versus stent placement on urinary complications.

For *patients with spinal cord injury*, very low-quality evidence suggested a benefit of avoiding indwelling urinary catheters.[54,56] This was based on a decreased risk of SUTI and bacteriuria in those without indwelling catheters (including patients managed with spontaneous voiding, clean intermittent catheterization [CIC], and external striated sphincterotomy with condom catheter drainage), as well as a lower risk of urinary complications, including hematuria, stones, and urethral injury (fistula, erosion, stricture).

For *children with myelomeningocele and neurogenic bladder*, very low-quality evidence suggested a benefit of CIC compared to urinary diversion or self voiding.[46,57,58] This was based on a decreased risk of bacteriuria/unspecified UTI in patients receiving CIC compared to urinary diversion, and a lower risk of urinary tract deterioration (defined by febrile urinary tract infection, vesicoureteral reflux, hydronephrosis, or increases in BUN or serum creatinine) compared to self-voiding and in those receiving CIC early (< 1 year of age) versus late (> 3 years of age).

Evidence Review Table 1A. When is urinary catheterization necessary?

1A.1. Use urinary catheters in operative patients only as necessary, rather than routinely. **(Category IB)**

1A.2. Avoid use of urinary catheters in patients and nursing home residents for management of incontinence. **(Category IB)**

1A.2.a. Further research is needed on periodic (e.g., nighttime) use of external catheters in incontinent patients or residents and the use of catheters to prevent skin breakdown. **(No recommendation/unresolved issue)**

1A.3. Further research is needed on the benefit of using a urethral stent as an alternative to an indwelling catheter in selected patients with bladder outlet obstruction. **(No recommendation/unresolved issue)**

1A.4. Consider alternatives to chronic indwelling catheters, such as intermittent catheterization, in spinal cord injury patients. **(Category II)**

1A.5. Consider intermittent catheterization in children with myelomeningocele and neurogenic bladder to reduce the risk of urinary tract deterioration. **(Category II)**

Q1B. What are the risk factors for CAUTI?

To answer this question, we reviewed the quality of evidence for those risk factors examined in more than one study. We considered the critical outcomes for decision-making to be SUTI and bacteriuria. The evidence for this question consists of 11 RCTs[59-69] and 37 observational studies.[9,50,54,70-103] The findings of the evidence review and the grades for all important outcomes are shown in Evidence Review Table 1B.

For *SUTI*, [50,54,61,62,74,75,79,83,102,103] low-quality evidence suggested that female sex, older age, prolonged catheterization, impaired immunity, and lack of antimicrobial exposure are risk factors. Very low quality evidence suggested that catheter blockage and low albumin level are also risk factors. For *bacteriuria*, [9,59-61,63-68,72,73,76-78,82,84-86,89-94,96-100] multiple risk factors were identified; there was high quality evidence for prolonged catheterization and moderate quality evidence for female sex, positive meatal cultures, and lack of antimicrobial exposure. Low-quality evidence also implicated the following risk factors for bacteriuria: older age, disconnection of the drainage system, diabetes, renal dysfunction, higher severity of illness, impaired immunity, placement of the catheter outside of the operating room, lower professional training of the person inserting the catheter, incontinence, and being on an orthopaedic or neurology service. Our search did not reveal data on adverse events and antimicrobial resistance associated with antimicrobial use, although one observational study found that the protective effect of antimicrobials lasted only for the first four days of catheterization, and that antimicrobial exposure led to changes in the epidemiology of bacterial flora in the urine.

Evidence Review Table 1B. What are the risk factors for CAUTI?

1B.1. Following aseptic insertion of the urinary catheter, maintain a closed drainage system. **(Category IB)**[a]

1B.2. Insert catheters only for appropriate indications, and leave in place only as long as needed. **(Category IB)**[b]

1B.3. Minimize urinary catheter use and duration of use in all patients, particularly those at higher risk for CAUTI such as women, the elderly, and patients with impaired immunity. **(Category IB)**

1B.4. Ensure that only properly trained persons (e.g., hospital personnel, family members, or patients themselves) who know the correct technique of aseptic catheter insertion and maintenance are given this responsibility. **(Category IB)**

1B.5. Maintain unobstructed urine flow. **(Category IB)**[c]

[a] More data are available under Question 2B.
[b] More data are available under Question 2C.
[c] More data are available under Question 2D.

Q1C. What populations are at highest risk of mortality from urinary catheters?

To answer this question, we reviewed the quality of evidence for those risk factors examined in more than one study. The evidence for this question consists of 2 observational studies.[7,74] The findings of the evidence review and the grades for all important outcomes are shown in Evidence Review Table 1C.

Low-quality evidence suggested that older age, higher severity of illness, and being on an internal medicine service compared to a surgical service were independent risk factors for mortality in patients with indwelling urinary catheters. Both studies evaluating these risk factors found the highest risk of mortality in patients over 70 years of age. Low-quality evidence also suggested that CAUTI was a risk factor for mortality in patients with catheters.

Evidence Review Table 1C. What populations are at highest risk of mortality from catheters?

1C.1. Minimize urinary catheter use and duration in all patients, particularly those who may be at higher risk for mortality due to catheterization, such as the elderly and patients with severe illness. **(Category IB)**

Q2. For those who may require urinary catheters, what are the best practices?

To answer this question, we focused on four subquestions: A) What are the risks and benefits associated with different approaches to catheterization?, B) What are the risks and benefits associated with different types of catheters or collecting systems?, C) What are the risks and benefits associated with different catheter management techniques, and D) What are the risks and benefits associated with different systems interventions?

Q2A. What are the risks and benefits associated with different approaches to catheterization?

The available data examined the following comparisons of different catheterization approaches:

1) External versus indwelling urethral
2) Intermittent versus indwelling urethral
3) Intermittent versus suprapubic
4) Suprapubic versus indwelling urethral
5) Clean intermittent versus sterile intermittent

For all comparisons, we considered SUTI, bacteriuria/unspecified UTI, or combinations of these outcomes depending on availability, as well as other outcomes critical to weighing the risks and benefits of different catheterization approaches. The evidence for this question consists of 6 systematic reviews,[37,104-108] 16 RCTs,[62,63,109-122] and 18 observational studies.[54,73,81,84,123-136] The findings of the evidence review and the grades for all important outcomes are shown in Evidence Review Table 2A

Q2A.1. External versus indwelling urethral

Low-quality evidence suggested a benefit of using external catheters over indwelling urethral catheters in male patients who require a urinary collection device but do not have an indication for an indwelling catheter such as urinary retention or bladder outlet obstruction.[81,109,123] This was based on a decreased risk of a composite outcome of SUTI, bacteriuria, or death as well as increased patient satisfaction with condom catheters. Differences were most pronounced in men without dementia. Statistically significant differences were not found or reported for the individual CAUTI outcomes or death. Our search did not reveal data on differences in local complications such as skin maceration or phimosis.

Q2A.2. Intermittent versus indwelling urethral

Low-quality evidence suggested a benefit of using intermittent catheterization over indwelling urethral catheters in selected populations.[84,104-106,110-114,124-126,135,136] This was based on a decreased risk of SUTI and bacteriuria/unspecified UTI but an increased risk of urinary retention in postoperative patients with intermittent catheterization. In one study, urinary retention and bladder distension were avoided by performing catheterization at regular intervals (every 6-8 hrs) until return of voiding. Studies of patients with neurogenic bladder most consistently found a decreased risk of CAUTI with intermittent catheterization. Studies in operative patients whose catheters were removed within 24 hrs of surgery found no differences in bacteriuria with intermittent vs. indwelling catheterization, while studies where catheters were left in for longer durations had mixed results. Our search did not reveal data on differences in patient satisfaction.

Q2A.3. Intermittent versus suprapubic

Very low-quality evidence suggested a benefit of intermittent over suprapubic catheterization in selected populations[115,116,134-136] based on increased patient acceptability and decreased risk of urinary complications (bladder calculi, vesicoureteral reflux, and upper tract abnormalities). Although we found a decreased risk of bacteriuria/unspecified UTI with suprapubic catheterization, there were no differences in SUTI. The populations studied included women undergoing urogynecologic surgery and spinal cord injury patients.

Q2A.4. Suprapubic versus indwelling urethral

Low-quality evidence suggested a benefit of suprapubic catheters over indwelling urethral catheters in selected populations.[37,62,104,107,108,128-133,135,136] This was based on a decreased risk of bacteriuria/unspecified UTI, recatheterization, and urethral stricture, and increased patient comfort and satisfaction. However, there were no differences in SUTI and an increased risk of longer duration of catheterization with suprapubic catheters. Studies involved primarily postoperative and spinal cord injury patients. Our search did not reveal data on differences in complications related to catheter insertion or the catheter site.

Q2A.5. Clean intermittent versus sterile intermittent

Moderate-quality evidence suggested no benefit of using sterile over clean technique for intermittent catheterization.[63,73,105,117-122] No differences were found in the risk of SUTI or bacteriuria/unspecified UTI. Study populations included nursing home residents and adults and children with neurogenic bladder/spinal cord injury.

Evidence Review Table 2A. What are the risks and benefits associated with different approaches to catheterization?

2A.1. Consider using external catheters as an alternative to indwelling urethral catheters in cooperative male patients without urinary retention or bladder outlet obstruction. **(Category II)**

2A.2. Intermittent catheterization is preferable to indwelling urethral or suprapubic catheters in patients with bladder emptying dysfunction. **(Category II)**

2A.3. If intermittent catheterization is used, perform it at regular intervals to prevent bladder overdistension. **(Category IB)**

2A.4. For operative patients who have an indication for an indwelling catheter, remove the catheter as soon as possible postoperatively, preferably within 24 hours, unless there are appropriate indications for continued use. **(Category IB)***

2A.5. Further research is needed on the risks and benefits of suprapubic catheters as an alternative to indwelling urethral catheters in selected patients requiring short- or long-term catheterization, particularly with respect to complications related to catheter insertion or the catheter site. **(No recommendation/unresolved issue)**

2A.6. In the non-acute care setting, clean (i.e., non-sterile) technique for intermittent catheterization is an acceptable and more practical alternative to sterile technique for patients requiring chronic intermittent catheterization. **(Category IA)**

* More data are available under Question 2C

Q2B. What are the risks and benefits associated with different catheters or collecting systems?

The available data examined the following comparisons between different types of catheters and drainage systems:

1. Antimicrobial/antiseptic catheters vs. standard catheters
    a. Silver-coated catheters vs. standard catheters
    b. Nitrofurazone-impregnated catheters vs. standard catheters
2. Hydrophilic catheters vs. standard catheters
3. Closed vs. open drainage systems
4. Complex vs. simple drainage systems
5. Preconnected/sealed junction catheters vs. standard catheters
6. Catheter valves vs. catheter bags

For all comparisons, we considered CAUTI outcomes as well as other outcomes critical to weighing the risks and benefits of different types of catheters or collecting systems. The evidence for this question consists of 5 systematic reviews,[37,137-140] 17 RCTs,[64,143-158] 23 observational studies,[82,86,89,97,159-163, 165-178] and 3 economic analyses.[179180,181] The findings of the evidence review and the grades for all important outcomes are shown in Evidence Review Table 2B.

Q2B.1.a. Silver-coated catheters vs. standard catheters

Low-quality evidence suggested a benefit of silver-coated catheters over standard latex catheters.[37,82,86,137-139,143,159-163, 165,166] This was based on a decreased risk of bacteriuria/unspecified UTI with silver-coated catheters and no evidence of increased urethral irritation or antimicrobial resistance in studies that reported data on microbiological outcomes. Differences were significant for silver alloy-coated catheters but not silver oxide-coated catheters. In a meta-analysis of randomized controlled trials (see Appendix), silver alloy-coated catheters reduced the risk of asymptomatic bacteriuria compared to standard latex catheters (control latex catheters were either uncoated or coated with hydrogel, Teflon®, or silicone), whereas there were no differences when compared to standard, all silicone catheters. The effect of silver alloy catheters compared to latex catheters was more pronounced when used in patients catheterized <1 week. The results were robust to inclusion or exclusion of non peer-reviewed studies. Only one observational study found a decrease in SUTI with silver alloy-coated catheters.[166] The setting was a burn referral center, where the control catheters were latex, and patients in the intervention group had new catheters placed on admission, whereas the control group did not. Recent observational studies in hospitalized patients found mixed results for bacteriuria/unspecified UTI.

Q2B.1.b. Nitrofurazone-impregnated catheters vs. standard catheters

Low-quality evidence suggested a benefit of nitrofurazone-impregnated catheters in patients catheterized for short periods of time.[137,138] This was based on a decreased risk of bacteriuria and no evidence of increased antimicrobial resistance in studies that reported microbiological outcomes. Differences were significant in a meta-analysis of three studies examining nitrofurazone-impregnated catheters (only one individual study significant) when duration of catheterization was <1 week. No differences were seen when duration of catheterization was >1 week, although the meta-analysis was borderline significant.

Q2B.2. Hydrophilic catheters vs. standard catheters

Very low-quality evidence suggested a benefit of hydrophilic catheters over standard non-hydrophilic catheters in specific populations undergoing clean intermittent catheterization.[137,144-148,169] This was based on a decreased risk of SUTI, bacteriuria, hematuria, and pain during insertion, and increased patient satisfaction. Differences in CAUTI outcomes were limited to one study of spinal cord injury patients and one study of patients receiving intravesical immunochemoprophylaxis for bladder cancer, while multiple other studies found no significant differences.

Q2B.3. Closed vs. open drainage systems

Very low-quality evidence suggested a benefit of using a closed rather than open urinary drainage system.[89,171] This was based on a decreased risk of bacteriuria with a closed drainage system. One study also found a suggestion of a decreased risk of SUTI, bacteremia, and UTI-related mortality associated with closed drainage systems, but differences were not statistically significant. Sterile, continuously closed drainage systems became the standard of care based on an uncontrolled study published in 1966 demonstrating a dramatic reduction in the risk of infection in short-term catheterized patients with the use of a closed system.[23] Recent data also include the finding that disconnection of the drainage system is a risk factor for bacteriuria (Q1B).

Q2B.4. Complex vs. simple drainage systems

Low-quality evidence suggested no benefit of complex closed urinary drainage systems over simple closed urinary drainage systems.[150-152,154,172,176,177] Although there was a decreased risk of bacteriuria with the complex systems, differences were found only in studies published before 1990, and not in more recent studies. The complex drainage systems studied included various mechanisms for reducing bacterial entry, such as antiseptic-releasing cartridges at the drain port of the urine collection bag; see evidence table for systems evaluated.

Q2B.5. Preconnected/sealed junction catheters vs. standard catheters

Low-quality evidence suggested a benefit of using preconnected catheters with junction seals over catheters with unsealed junctions to reduce the risk of disconnections.[64,153,156,175] This was based on a decreased risk of SUTI and bacteriuria with preconnected sealed catheters. Studies that found differences had higher rates of CAUTI in the control group than studies that did not find an effect.

Q2B.6. Catheter valves vs. drainage bags

Moderate-quality evidence suggested a benefit of catheter valves over drainage bags in selected patients with indwelling urinary catheters.[140] Catheter valves led to greater patient satisfaction but no differences in bacteriuria/unspecified UTI or pain/bladder spasms. Details regarding the setting for recruitment and follow-up of the patients in the studies were unclear, and the majority of subjects were men. Our search did not reveal data on the effect of catheter valves on bladder function, bladder/urethral trauma, or catheter blockage.

Evidence Review Table 2B. What are the risks and benefits associated with different catheters or collecting systems?

2B.1. If the CAUTI rate is not decreasing after implementing a comprehensive strategy to reduce rates of CAUTI, consider using antimicrobial/antiseptic-impregnated catheters. The comprehensive strategy should include, at a minimum, the high priority recommendations for urinary catheter use, aseptic insertion, and maintenance (see Section III. Implementation and Audit). **(Category IB)**

2B.1.a. Further research is needed on the effect of antimicrobial/antiseptic-impregnated catheters in reducing the risk of symptomatic UTI, their inclusion among the primary interventions, and the patient populations most likely to benefit from these catheters. **(No recommendation/unresolved issue)**

2B.2. Hydrophilic catheters might be preferable to standard catheters for patients requiring intermittent catheterization. **(Category II)**

2B.3. Following aseptic insertion of the urinary catheter, maintain a closed drainage system. **(Category IB)**

2B.4. Complex urinary drainage systems (utilizing mechanisms for reducing bacterial entry such as antiseptic-release cartridges in the drain port) are not necessary for routine use. **(Category II)**

2B.5. Urinary catheter systems with preconnected, sealed catheter-tubing junctions are suggested for use. **(Category II)**

2B.6. Further research is needed to clarify the benefit of catheter valves in reducing the risk of CAUTI and other urinary complications. **(No recommendation/unresolved issue)**

Q2C. What are the risks and benefits associated with different catheter management techniques?

The available data examined the following catheter management techniques:

1. Antimicrobial prophylaxis
2. Urinary antiseptics (i.e., methanamine)
3. Bladder irrigation
4. Antiseptic instillation in the drainage bag
5. Periurethral care
6. Routine catheter or bag change
7. Catheter lubricants
8. Securing devices
9. Bacterial interference
10. Catheter cleansing
11. Catheter removal strategies (clamping vs. free drainage prior to removal, postoperative duration of catheterization)
12. Assessment of urine volumes

For all comparisons, we considered CAUTI outcomes as well as other outcomes critical to weighing the risks and benefits of different catheter management techniques. The evidence for this question consists of 6 systematic reviews,[37,105,106,182-184] 56 RCTs,[60,61,65-69,143,158,158,185-231] 34 observational studies,[83,85,88,90,96,102,133,167,178,232-258] and 1 economic analysis.[180] The findings of the evidence review and the grades for all important outcomes are shown in Evidence Review Table 2C.

Q2C.1. Antimicrobial prophylaxis

Low-quality evidence suggested no benefit of antimicrobial prophylaxis in patients undergoing short-term catheterization.[37,60,61,83,85,133,158,178,182,185,186,189-191,232-234] This was based on heterogeneous results for SUTI and bacteriuria/unspecified UTI and no adverse events related to antimicrobials. Lack of consistency in specific factors, such as patient population, antimicrobial agents, timing of administration, and duration of follow-up, did not allow for a summary of evidence of the effect of antimicrobial prophylaxis on CAUTI in patients undergoing short term catheterization. Only two studies evaluated adverse events related to antimicrobials. Our search did not reveal data on antimicrobial resistance or *Clostridium difficile* infection.

Low-quality evidence suggested no benefit of antimicrobial prophylaxis in patients undergoing long-term catheterization (indwelling and clean intermittent catheterization).[106,183,192,194,235,238] This was based on a decreased risk of bacteriuria, heterogeneous results for SUTI, and no differences reported for catheter encrustation or adverse events, although data were sparse. One systematic review suggested an increase in antimicrobial resistance with antimicrobial use.

Q2C.2. Urinary antiseptics

Low-quality evidence suggested a benefit of methenamine for short-term catheterized patients.[196,197] This was based on a reduced risk of SUTI and bacteriuria and no differences in adverse events. Evidence was limited to two studies of patients following gynecological surgery in Norway and Sweden.

Very low-quality evidence suggested a benefit of methanamine for long-term catheterized patients.[106,236-239] This was based on a reduced risk of encrustation but no differences in risk of SUTI or bacteriuria. Data on encrustation was limited to one study. Studies involved primarily elderly and spinal cord injury patients with chronic indwelling catheters

Q2C.3. Bladder irrigation

Low-quality evidence suggested no benefit of bladder irrigation in patients with indwelling or intermittent catheters.[66,69,199-206,240-242] This was based on no differences in SUTI and heterogeneous findings for bacteriuria.

Q2C.4. Antiseptic instillation in the drainage bag

Low-quality evidence suggested no benefit of antiseptic instillation in urinary drainage bags.[90,207-211,243-245] This was based on no differences in SUTI and heterogeneous results for bacteriuria.

Q2C.5. Periurethral care

Low-quality evidence suggested no benefit of antiseptic meatal cleaning regimens before or during catheterization to prevent CAUTI.[65,67,68,88,158,212-216,246,247] This was based on no difference in the risk of bacteriuria in patients receiving periurethral care regimens compared to those not receiving them. One study found a higher risk of bacteriuria with cleaning of the urethral meatus-catheter junction (either twice daily application of povidine-iodine or once daily cleaning with a non-antiseptic solution of green soap and water) in a subgroup of women with positive meatal cultures and in patients not receiving antimicrobials. Periurethral cleaning with chlorhexidine before catheter insertion did not have an effect in two studies.

Q2C.6. Routine catheter or bag change

Low-quality evidence suggested no benefit of routine catheter or drainage bag changes to prevent CAUTI.[102,217-219,248,249] This was based on no difference or an increased risk of SUTI and no difference in bacteriuria with routine compared to as-needed changes or with more frequent changing intervals. One study in nursing home residents found no differences in SUTI with routine monthly catheter changes compared to changing only for obstruction or infection, but the study was underpowered to detect a difference. Another study in home care patients found an increased risk of SUTI when catheters were changed more frequently than monthly.

Q2C.7. Catheter lubricants

Very low-quality evidence suggested a benefit of using lubricants for catheter insertion.[167,220-223,250-254] This was based on a decreased risk of SUTI and bacteriuria with the use of a pre-lubricated catheter compared to a catheter lubricated by the patient and a decreased risk of bacteriuria with use of a lubricant versus no lubricant. Studies were heterogeneous both in the interventions and outcomes studied. Several studies comparing antiseptic lubricants to non-antiseptic lubricants found no significant differences.

Q2C.8. Securing devices

Low-quality evidence suggested no benefit of using catheter securing devices to prevent CAUTI.[224] This was based on no significant difference in the risk of SUTI or meatal erosion. The only study in this category looked at one particular product.

Q2C.9. Bacterial interference

Moderate-quality evidence suggested a benefit of using bacterial interference in catheterized patients.[225] In the one study evaluating this intervention, urinary colonization with a non-pathogenic *Escherichia coli* was associated with a decreased risk of SUTI in adults with spinal cord injury and a history of frequent CAUTI.

Q2C.10. Catheter cleansing

Very low-quality evidence suggested a benefit of wet versus dry storage procedures for catheters used in clean intermittent catheterization.[255] This was based on a decreased risk of SUTI with a wet storage procedure in one study of spinal cord injury patients undergoing clean intermittent catheterization compared to a dry storage procedure where the catheter was left to air dry after washing. In the wet procedure, the catheter was stored in a dilute povidone-iodine solution after washing with soap and water.

Q2C.11. Catheter removal strategies

a. Clamping vs. free drainage prior to removal

Low-quality evidence suggested no benefit of clamping versus free drainage before catheter removal.[37,184] This was based on no difference in risk of bacteriuria, urinary retention, or recatheterization between the two strategies. One study comparing a clamp and release strategy to free drainage over 72 hours found a greater risk of bacteriuria in the clamping group.

b. Postoperative duration of catheterization

Moderate-quality evidence suggested a benefit of shorter versus longer postoperative durations of catheterization.[37,184,227,228] This was based on a decreased risk of bacteriuria/unspecified UTI, decreased time to ambulation and length of stay, no differences in urinary retention and SUTI, and increased risk of recatheterization. Significant decreases in bacteriuria/unspecified UTI were found specifically for comparisons of 1 day versus 3 or 5 days of postoperative catheterization. Recatheterization risk was greater in only one study comparing immediate removal to removal 6 or 12 hours after hysterectomy.

Q2C.12. Assessment of urine volumes

Low-quality evidence suggested a benefit of using portable ultrasound to assess urine volume in patients undergoing intermittent catheterization.[229,230] This was based on fewer catheterizations but no reported differences in risk of unspecified UTI. Patients studied were adults with neurogenic bladder in inpatient rehabilitation centers. Our search did not reveal data on the use of ultrasound in catheterized patients in other settings.

Evidence Review Table 2C. What are the risks and benefits associated with different catheter management techniques?

2C.1. Unless clinical indications exist (e.g., in patients with bacteriuria upon catheter removal post urologic surgery), do not use systemic antimicrobials routinely as prophylaxis for UTI in patients requiring either short or long-term catheterization. **(Category IB)**

2C.2.a. Further research is needed on the use of urinary antiseptics (e.g., methanamine) to prevent UTI in patients requiring short-term catheterization. **(No recommendation/unresolved issue)**
2C.2.b. Further research is needed on the use of methanamine to prevent encrustation in patients requiring chronic indwelling catheters who are at high risk for obstruction. **(No recommendation/unresolved issue)**

2C.3.a. Unless obstruction is anticipated (e.g., as might occur with bleeding after prostatic or bladder surgery), bladder irrigation is not recommended. **(Category II)**
2C.3.b. Routine irrigation of the bladder with antimicrobials is not recommended. **(Category II)**

2C.4. Routine instillation of antiseptic or antimicrobial solutions into urinary drainage bags is not recommended. **(Category II)**

2C.5.a. Do not clean the periurethral area with antiseptics to prevent CAUTI while the catheter is in place. Routine hygiene (e.g., cleansing of the meatal surface during daily bathing) is

appropriate. **(Category IB)**
2C.5.b. Further research is needed on the use of antiseptic solutions vs. sterile water or saline for periurethral cleaning prior to catheter insertion. **(No recommendation/unresolved issue)**

2C.6. Changing indwelling catheters or drainage bags at routine, fixed intervals is not recommended. Rather, catheters and drainage bags should be changed based on clinical indications such as infection, obstruction, or when the closed system is compromised. **(Category II)**

2C.7.a. Use a sterile, single-use packet of lubricant jelly for catheter insertion. **(Category IB)**
2C.7.b. Routine use of antiseptic lubricants is not necessary. **(Category II)**

2C.8. Further research is needed on the use of bacterial interference to prevent UTI in patients requiring chronic urinary catheterization. **(No recommendation/unresolved issue)**

2C.9. Further research is needed on optimal cleaning and storage methods for catheters used for clean intermittent catheterization. **(No recommendation/unresolved issue)**

2C.10.a. Clamping indwelling catheters prior to removal is not necessary. **(Category II)**
2C.10.b. Insert catheters only for appropriate indications, and leave in place only as long as needed. **(Category IB)**
2C.10.c. For operative patients who have an indication for an indwelling catheter, remove the catheter as soon as possible postoperatively, preferably within 24 hours, unless there are appropriate indications for continued use. **(Category IB)**

2C.11.a. Consider using a portable ultrasound device to assess urine volume in patients undergoing intermittent catheterization to assess urine volume and reduce unnecessary catheter insertions. **(Category II)**
2C.11.b. Further research is needed on the use of a portable ultrasound device to evaluate for obstruction in patients with indwelling catheters and low urine output. **(No recommendation/unresolved issue)**

Q2D. What are the risks and benefits associated with different systems interventions?

The available data examined the following systems interventions:

1. Infection control/quality improvement programs (multifaceted)
2. Catheter reminders
3. Bacteriologic monitoring
4. Hand hygiene
5. Patient placement
6. Catheter team versus self-catheterization
7. Feedback
8. Nurse-directed catheter removal

We considered CAUTI outcomes, duration of catheterization, recatheterization, and transmission of pathogens when weighing the risks and benefits of different systems interventions. The evidence for this question consists of 1 RCT[259] and 19 observational

studies.[3,25,260-276] The findings of the evidence review and the grades for all important outcomes are shown in Evidence Review Table 2D.

Q2D.1. Multifaceted infection control/quality improvement programs

Low-quality evidence suggested a benefit of multifaceted infection control/quality improvement programs to reduce the risk of CAUTI.[3,260-267] This was based on a decreased risk of SUTI, bacteriuria/unspecified UTI, and duration of catheter use with implementation of such programs. Studies evaluated various multifaceted interventions. The studies with significant findings included: 1) education and performance feedback regarding compliance with catheter care, emphasizing hand hygiene, and maintaining unobstructed urine flow; 2) computerized alerts to physicians, nurse-driven protocols to remove catheters, and use of handheld bladder scanners to assess for urinary retention; 3) guidelines and education focusing on perioperative catheter management; and 4) a multifaceted infection control program including guidelines for catheter insertion and maintenance. A program using a checklist and algorithm for appropriate catheter use also suggested a decrease in unspecified UTI and catheter duration, but statistical differences were not reported.

Q2D.2. Reminders

Very low-quality evidence suggested a benefit of using urinary catheter reminders to prevent CAUTI.[268-270] This was based on a decreased risk of bacteriuria and duration of catheterization and no differences in recatheterization or SUTI when reminders were used. Reminders to physicians included both computerized and non-computerized alerts about the presence of urinary catheters and the need to remove unnecessary catheters.

Q2D.3. Bacteriologic monitoring

Very low-quality evidence suggested no benefit of bacteriologic monitoring to prevent CAUTI.[25,271] Although one study found a decreased risk of bacteriuria during a period of bacteriologic monitoring and feedback, only 2% of SUTI episodes were considered potentially preventable with the use of bacteriologic monitoring.

Q2D.4. Hand hygiene

Very low-quality evidence suggested a benefit of using alcohol hand sanitizer in reducing CAUTI. This was based on one study in a rehabilitation facility that found a decrease in unspecified UTI, although no statistical differences were reported.[272] A separate multifaceted study that included education and performance feedback on compliance with catheter care and hand hygiene showed a decrease in risk of SUTI.[265]

Q2D.5. Patient placement

Very low-quality evidence suggested a benefit of spatially separating patients to prevent transmission of urinary pathogens.[273] This was based on a decreased risk of transmission of urinary bacterial pathogens in nursing home residents in separate rooms compared to residents in the same rooms.

Q2D.6. Catheter team versus self-catheterization

Very low-quality evidence suggested no benefit of a catheter team to prevent CAUTI among patients requiring intermittent catheterization.[274] This was based on one study showing no difference in unspecified UTI between use of a catheter care team and self-catheterization for intermittent catheterization in paraplegic patients.

Q2D.7. Feedback

Very low-quality evidence suggested a benefit of using nursing feedback to prevent CAUTI.[275] This was based on a decreased risk of unspecified UTI during an intervention where nursing staff were provided with regular reports of unit-specific rates of CAUTI.

Q2D.8. Nurse-directed catheter removal

Very low-quality evidence suggested a benefit of a nurse-directed catheter removal program to prevent CAUTI.[276] This was based on a decreased risk of unspecified UTI during an intervention where criteria were developed that allowed a registered nurse to remove a catheter without a physician's order when no longer medically necessary. Of the three intensive care units where the intervention was implemented, differences were significant only in the coronary intensive care unit.

Evidence Review Table 2D. What are the risks and benefits associated with different systems interventions?

2D.1.a. Ensure that healthcare personnel and others who take care of catheters are given periodic in-service training stressing the correct techniques and procedures for urinary catheter insertion, maintenance, and removal. **(Category IB)**
2D.1.b. Implement quality improvement (QI) programs or strategies to enhance appropriate use of indwelling catheters and to reduce the risk of CAUTI based on a facility risk assessment. **(Category IB)**

Examples of programs that have been demonstrated to be effective include:

1. A system of alerts or reminders to identify all patients with urinary catheters and assess the need for continued catheterization
2. Guidelines and protocols for nurse-directed removal of unnecessary urinary catheters
3. Education and performance feedback regarding appropriate use, hand hygiene, and catheter care
4. Guidelines and algorithms for appropriate peri-operative catheter management, such as:
    a. Procedure-specific guidelines for catheter placement and postoperative catheter removal
    b. Protocols for management of postoperative urinary retention, such as nurse-directed use of intermittent catheterization and use of ultrasound bladder scanners

2D.2. Routine screening of catheterized patients for asymptomatic bacteriuria is not recommended. **(Category II)**

2D.3. Perform hand hygiene immediately before and after insertion or any manipulation of the catheter site or device. **(Category IB)**

2D.5. Maintain unobstructed urine flow. **(Category IB)**

2D.6. Further research is needed on the benefit of spatial separation of patients with urinary catheters to prevent transmission of pathogens colonizing urinary drainage systems. **(No recommendation/unresolved issue)**

2D.7. When performing surveillance for CAUTI, consider providing regular (e.g., quarterly) feedback of unit-specific CAUTI rates to nursing staff and other appropriate clinical care staff. **(Category II)**

Q3: What are the best practices for preventing UTI associated with obstructed urinary catheters?

The available data examined the following practices:

1. Methods to prevent/reduce encrustations or blockage
2. Catheter materials preventing blockage

For this question, available relevant outcomes included blockage/encrustation. We did not find data on the outcomes of CAUTI. The evidence for this question consists of 1 systematic review,[277] 2 RCTs,[278,279] and 2 observational studies.[280,281] The findings of the evidence review and the grades for all important outcomes are shown in Evidence Review Table 3.

Q3.1. Methods to prevent/reduce encrustations or blockage

Low-quality evidence suggested a benefit of acidifying solutions or oral acetohydroxamic acid in preventing or reducing catheter encrustations and blockage in long-term catheterized patients.[277,278,280,281] No differences were seen with daily catheter irrigation with normal saline.

Q3.2. Catheter materials preventing blockage

Low-quality evidence suggested a benefit of silicone over latex or Teflon-coated catheters in prevention or reducing catheter encrustations in long-term catheterized patients who were prone to blockage. No differences were seen with different materials in patients considered "non-blockers."[279]

Evidence Review Table 3. What are the best practices for preventing UTI associated with obstructed urinary catheters?

3.1.a. Further research is needed on the benefit of irrigating the catheter with acidifying solutions or use of oral urease inhibitors in long-term catheterized patients who have frequent catheter obstruction. **(No recommendation/unresolved issue)**

3.2.a. Silicone might be preferable to other materials to reduce the risk of encrustation in long-term catheterized patients who have frequent obstruction. **(Category II)**

References

1. Wong ES. Guideline for prevention of catheter-associated urinary tract infections. *Am J Infect Control*. 1983;11(1):28-36.

2. Lo E, Nicolle L, Classen D, et al. Strategies to prevent catheter-associated urinary tract infections in acute care hospitals. *Infect Control Hosp Epidemiol*. 2008;29:S41-S50.

3. Stephan F, Sax H, Wachsmuth M, Hoffmeyer P, Clergue F, Pittet D. Reduction of urinary tract infection and antibiotic use after surgery: A controlled, prospective, before-after intervention study. *Clin Infect Dis*. 2006;42(11):1544-1551.

4. Dolin SJ, Cashman JN. Tolerability of acute postoperative pain management: Nausea, vomiting, sedation, pruritis, and urinary retention. evidence from published data. *Br J Anaesth*. 2005;95(5):584-591.

5. Hidron AI, Edwards JR, Patel J, et al. NHSN annual update: Antimicrobial-resistant pathogens associated with healthcare-associated infections: Annual summary of data reported to the national healthcare safety network at the centers for disease control and prevention, 2006-2007. *Infect Control Hosp Epidemiol*. 2008;29(11):996-1011.

6. Saint S. Clinical and economic consequences of nosocomial catheter-related bacteriuria. *Am J Infect Control*. 2000;28(1):68-75.

7. Platt R, Polk BF, Murdock B, Rosner B. Mortality associated with nosocomial urinary-tract infection. *N Engl J Med*. 1982;307(11):637-642.

8. Givens CD, Wenzel RP. Catheter-associated urinary tract infections in surgical patients: A controlled study on the excess morbidity and costs. *J Urol*. 1980;124(5):646-648.

9. Tambyah PA, Knasinski V, Maki DG. The direct costs of nosocomial catheter-associated urinary tract infection in the era of managed care. *Infect Control Hosp Epidemiol*. 2002;23(1):27-31.

10. Schaberg DR, Weinstein RA, Stamm WE. Epidemics of nosocomial urinary tract infection caused by multiply resistant gram-negative bacilli: Epidemiology and control. *J Infect Dis*. 1976;133(3):363-366.

11. Yoon HJ, Choi JY, Park YS, et al. Outbreaks of serratia marcescens bacteriuria in a neurosurgical intensive care unit of a tertiary care teaching hospital: A clinical, epidemiologic, and laboratory perspective. *Am J Infect Control*. 2005;33(10):595-601.

12. Warren JW. Catheter-associated urinary tract infections. *Int J Antimicrob Agents*. 2001;17(4):299-303.

13. Weinstein JW, Mazon D, Pantelick E, Reagan-Cirincione P, Dembry LM, Hierholzer WJ,Jr. A decade of prevalence surveys in a tertiary-care center: Trends in nosocomial infection rates, device utilization, and patient acuity. *Infect Control Hosp Epidemiol*. 1999;20(8):543-548.

14. Munasinghe RL, Yazdani H, Siddique M, Hafeez W. Appropriateness of use of indwelling urinary catheters in patients admitted to the medical service. *Infect Control Hosp Epidemiol*. 2001;22(10):647-649.

15. Jain P, Parada JP, David A, Smith LG. Overuse of the indwelling urinary tract catheter in hospitalized medical patients. *Arch Intern Med*. 1995;155(13):1425-1429.

16. Saint S, Wiese J, Amory JK, et al. Are physicians aware of which of their patients have indwelling urinary catheters? *Am J Med*. 2000;109(6):476-480.

17. Edwards JR, Peterson KD, Andrus ML, et al. National healthcare safety network (NHSN) report, data summary for 2006, issued june 2007. *Am J Infect Control*. 2007;35(5):290-301.

18. Rogers MA, Mody L, Kaufman SR, Fries BE, McMahon LF,Jr, Saint S. Use of urinary collection devices in skilled nursing facilities in five states. *J Am Geriatr Soc*. 2008;56(5):854-861.

19. Klevens RM, Edwards JR, Richards CL,Jr, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. *Public Health Rep*. 2007;122(2):160-166.

20. Weinstein MP, Towns ML, Quartey SM, et al. The clinical significance of positive blood cultures in the 1990s: A prospective comprehensive evaluation of the microbiology, epidemiology, and outcome of bacteremia and fungemia in adults. *Clin Infect Dis*. 1997;24(4):584-602.

21. Muder RR, Brennen C, Wagener MM, Goetz AM. Bacteremia in a long-term-care facility: A five-year prospective study of 163 consecutive episodes. *Clin Infect Dis*. 1992;14(3):647-654.

22. Umscheid C, Mitchell M, Agarwal R, Williams K, Brennan P. Mortality from reasonably-preventable hospital acquired infections. included in written testimony by the society of healthcare epidemiology of america for the committee on oversight and government reform hearing on healthcare-associated infections: A preventable epidemic, chaired by henry A. waxman, april 16, 2008, washington, DC. [congressional testimony]. .

23. Kunin CM, McCormack RC. Prevention of catheter-induced urinary-tract infections by sterile closed drainage. *N Engl J Med*. 1966;274(21):1155-1161.

24. Tambyah PA, Halvorson KT, Maki DG. A prospective study of pathogenesis of catheter-associated urinary tract infections. *Mayo Clin Proc*. 1999;74(2):131-136.

25. Garibaldi RA, Mooney BR, Epstein BJ, Britt MR. An evaluation of daily bacteriologic monitoring to identify preventable episodes of catheter-associated urinary tract infection. *Infect Control*. 1982;3(6):466-470.

26. Saint S, Lipsky BA, Goold SD. Indwelling urinary catheters: A one-point restraint? *Ann Intern Med*. 2002;137(2):125-127.

27. Warren JW, Tenney JH, Hoopes JM, Muncie HL, Anthony WC. A prospective microbiologic study of bacteriuria in patients with chronic indwelling urethral catheters. *J Infect Dis*. 1982;146(6):719-723.

28. Saint S, Chenoweth CE. Biofilms and catheter-associated urinary tract infections. *Infect Dis Clin North Am*. 2003;17(2):411-432.

29. Kallen AJ, Hidron AI, Edwards JR, Patel J, Srinivasan A. Antibiotic resistance among important gram-negative pathogens causing healthcare-associated infections reported to the national healthcare safety network, 2006-2007 [abstract 376] in: Program and abstracts of the 18th annual scientific meeting of the society for healthcare epidemiology of america, orlando, FL, apr 5-8, 2008. .

30. Horan TC, Gaynes RP. Surveillance of nosocomial infections. In: Mayhall CG, ed. *Hospital Epidemiology and Infection Control.* 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2004:1659-1702.

31. Tambyah PA, Maki DG. Catheter-associated urinary tract infection is rarely symptomatic: A prospective study of 1,497 catheterized patients. *Arch Intern Med*. 2000;160(5):678-682.

32. Atkins D, Best D, Briss PA, et al. Grading quality of evidence and strength of recommendations. *BMJ.* 2004;328(7454):1490.

33. Guyatt GH, Oxman AD, Kunz R, et al. Going from evidence to recommendations. *BMJ*. 2008;336(7652):1049-1051.

34. Guyatt GH, Oxman AD, Kunz R, et al. What is "quality of evidence" and why is it important to clinicians? *BMJ*. 2008;336(7651):995-998.

35. Pratt RJ, Pellowe CM, Wilson JA, et al. epic2: National evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in england. *J Hosp Infect*. 2007;65(Suppl 1):S1-64.

36. Pellowe CM, Pratt RJ, Harper P, et al. Evidence-based guidelines for preventing healthcare-associated infections in primary and community care in england. *J Hosp Infect*. 2003;55(Suppl 2):S2-127.

37. Phipps S, Lim YN, McClinton S, Barry C, Rane A, N'Dow J. Short term urinary catheter policies following urogenital surgery in adults. *Cochrane Database Syst Rev*. 2006(2):CD004374.

38. Tang KK, Wong CK, Lo SF, Ng TK. Is it necessary to catheterise the bladder routinely before gynaecological laparoscopic surgery? *Aust N Z J Obstet Gynaecol*. 2005;45(5):380-383.

39. Iorio R, Healy WL, Patch DA, Appleby D. The role of bladder catheterization in total knee arthroplasty. *Clin Orthop*. 2000(380):80-84.

40. Liu SK, Rassai H, Krasner C, Braun J, Matolo NM. Urinary catheter in laparoscopic cholecystectomy: Is it necessary? *Surg Laparosc Endosc Percutan Tech*. 1999;9(3):184-186.

41. Normelli H, Aaro S, Hedlund R, Svensson O, Stromberg L. Urethral catheterization in spinal surgery: A randomized prospective study. *Eur Spine J*. 1993;2(3):132-135.

42. Carpiniello VL, Cendron M, Altman HG, Malloy TR, Booth R. Treatment of urinary complications after total joint replacement in elderly females. *Urology*. 1988;32(3):186-188.

43. Akhtar MS, Beere DM, Wright JT, MacRae KD. Is bladder catheterization really necessary before laparoscopy? *Br J Obstet Gynaecol*. 1985;92(11):1176-1178.

44. Chaudhuri P, Vengadasalam D. Urinary tract infection following abdominal delivery--second thought on indwelling catheter. *Singapore Med J*. 1983;24(4):224-226.

45. McMurdo ME, Davey PG, Elder MA, Miller RM, Old DC, Malek M. A cost-effectiveness study of the management of intractable urinary incontinence by urinary catheterisation or incontinence pads. *J Epidemiol Community Health*. 1992;46(3):222-226.

46. Geraniotis E, Koff SA, Enrile B. The prophylactic use of clean intermittent catheterization in the treatment of infants and young children with myelomeningocele and neurogenic bladder dysfunction. *J Urol*. 1988;139(1):85-86.

47. Kumar P, Mannan K, Chowdhury AM, Kong KC, Pati J. Urinary retention and the role of indwelling catheterization following total knee arthroplasty. *Int Braz J Urol*. 2006;32(1):31-34.

48. Miskry T, Cumbis A, Apostolidis P, Eleftheriou M, Magos A. Do not catheterize the bladder at operative laparoscopy. *Gynaecol Endosc*. 2001;10(1):29-32.

49. Barnes JS. Is it better to avoid urethral catheterization at hysterectomy and caesarean section? *Aust N Z J Obstet Gynaecol*. 1998;38(3):315-316.

50. Ouslander JG, Greengold B, Chen S. External catheter use and urinary tract infections among incontinent male nursing home patients. *J Am Geriatr Soc*. 1987;35(12):1063-1070.

51. Rannikko S, Kyllastinen M, Granqvist B. Comparison of long-term indwelling catheters and bed-pads in the treatment of urinary incontinence in elderly patients. *J Infect*. 1986;12(3):221-227.

52. Nordqvist P, Ekelund P, Edouard L, Svensson ML, Brandberg A, Seeberg S. Catheter-free geriatric care. routines and consequences for clinical infection, care and economy. *J Hosp Infect*. 1984;5(3):298-304.

53. Egilmez T, Aridogan IA, Yachia D, Hassin D. Comparison of nitinol urethral stent infections with indwelling catheter-associated urinary-tract infections. *J Endourol*. 2006;20(4):272-277.

54. Ruz ED, Garcia Leoni E, Herruzo Cabrera R. Epidemiology and risk factors for urinary tract infection in patients with spinal cord injury. *J Urol*. 2000;164(4):1285-1289.

55. Donovan WH, Stolov WC, Clowers DE, et al. Bacteriuria during intermittent catheterization following spinal cord injury. *Arch Phys Med Rehabil*. 1978;59(8):351-357.

56. Larsen LD, Chamberlin DA, Khonsari F, Ahlering TE. Retrospective analysis of urologic complications in male patients with spinal cord injury managed with and without indwelling urinary catheters. *Urology*. 1997;50(3):418-422.

57. Kochakarn W, Ratana-Olarn K, Lertsithichai P, Roongreungsilp U. Follow-up of long-term treatment with clean intermittent catheterization for neurogenic bladder in children. *Asian J*. 2004;27(2):134-136.

58. Ehrlich O, Brem AS. A prospective comparison of urinary tract infections in patients treated with either clean intermittent catheterization or urinary diversion. *Pediatrics*. 1982;70(5):665-669.

59. Darouiche RO, Smith JA,Jr., Hanna H, et al. Efficacy of antimicrobial-impregnated bladder catheters in reducing catheter-associated bacteriuria: A prospective, randomized, multicenter clinical trial. *Urology*. 1999;54(6):976-981.

60. Stricker PD, Grant AB. Relative value of antibiotics and catheter care in the prevention of urinary tract infection after transurethral prostatic resection. *Br J Urol*. 1988;61(6):494-497.

61. Rogers RG, Kammerer-Doak D, Olsen A, et al. A randomized, double-blind, placebo-controlled comparison of the effect of nitrofurantoin monohydrate macrocrystals on the development of urinary tract infections after surgery for pelvic organ prolapse and/or stress urinary incontinence with suprapubic catheterization. *Obstet Gynecol*. 2004;191(1):182-187.

62. Baan AH, Vermeulen H, van der Meulen, J., Bossuyt P, Olszyna D, Gouma DJ. The effect of suprapubic catheterization versus transurethral catheterization after abdominal surgery on urinary tract infection: A randomized controlled trial. *Dig Surg*. 2003;20(4):290-295.

63. Carapeti EA, Andrews SM, Bentley PG. Randomised study of sterile versus non-sterile urethral catheterisation.[erratum appears in ann R coll surg engl 1996 may;78(3 pt 1):167]. *Ann R Coll Surg Engl*. 1996;78(1):59-60.

64. Huth TS, Burke JP, Larsen RA, Classen DC, Stevens LE. Clinical trial of junction seals for the prevention of urinary catheter-associated bacteriuria. *Arch Intern Med*. 1992;152(4):807-812.

65. Huth TS, Burke JP, Larsen RA, Classen DC, Stevens LE. Randomized trial of meatal care with silver sulfadiazine cream for the prevention of catheter-associated bacteriuria. *J Infect Dis*. 1992;165(1):14-18.

66. Schneeberger PM, Vreede RW, Bogdanowicz JF, van Dijk, W. C. A randomized study on the effect of bladder irrigation with povidone-iodine before removal of an indwelling catheter. *J Hosp Infect*. 1992;21(3):223-229.

67. Burke JP, Jacobson JA, Garibaldi RA, Conti MT, Alling DW. Evaluation of daily meatal care with poly-antibiotic ointment in prevention of urinary catheter-associated bacteriuria. *J Urol*. 1983;129(2):331-334.

68. Classen DC, Larsen RA, Burke JP, Alling DW, Stevens LE. Daily meatal care for prevention of catheter-associated bacteriuria: Results using frequent applications of polyantibiotic cream. *Infect Control Hosp Epidemiol*. 1991;12(3):157-162.

69. Warren JW, Platt R, Thomas RJ, Rosner B, Kass EH. Antibiotic irrigation and catheter-associated urinary-tract infections. *N Engl J Med*. 1978;299(11):570-573.

70. Seki N, Masuda K, Kinukawa N, Senoh K, Naito S. Risk factors for febrile urinary tract infection in children with myelodysplasia treated by clean intermittent catheterization. *Int J Urol*. 2004;11(11):973-977.

71. Kelleher RE, Meeropol E, Parks D. Factors influencing the development of symptomatic bacteriuria in children on clean intermittent catheterization. *J Urol Nurs*. 1996;15(2):1256-1265.

72. Waites KB, Canupp KC, DeVivo MJ. Epidemiology and risk factors for urinary tract infection following spinal cord injury. *Arch Phys Med Rehabil*. 1993;74(7):691-695.

73. Anderson RU. Non-sterile intermittent catheterization with antibiotic prophylaxis in the acute spinal cord injured male patient. *J Urol*. 1980;124(3):392-394.

74. Van Der Kooi, T. I. I., De Boer, A. S., Mannien J, et al. Incidence and risk factors of device-associated infections and associated mortality at the intensive care in the dutch surveillance system. *Intensive Care Med*. 2007;33(2):271-278.

75. Bochicchio GV, Joshi M, Shih D, Bochicchio K, Tracy K, Scalea TM. Reclassification of urinary tract infections in critically III trauma patients: A time-dependent analysis. *Surg Infect*. 2003;4(4):379-385.

76. Leone M, Albanese J, Garnier F, et al. Risk factors of nosocomial catheter-associated urinary tract infection in a polyvalent intensive care unit. *Intensive Care Med*. 2003;29(7):1077-1080.

77. Tissot E, Limat S, Cornette C, Capellier G. Risk factors for catheter-associated bacteriuria in a medical intensive care unit. *Eur J Clin Microbiol Infect Dis*. 2001;20(4):260-262.

78. Colau A, Lucet JC, Rufat P, Botto H, Benoit G, Jardin A. Incidence and risk factors of bacteriuria after transurethral resection of the prostate. *Eur Urol*. 2001;39(3):272-276.

79. Ouslander JG, Greengold B, Chen S. Complications of chronic indwelling urinary catheters among male nursing home patients: A prospective study. *J Urol*. 1987;138(5):1191-1195.

80. Hazelett SE, Tsai M, Gareri M, Allen K. The association between indwelling urinary catheter use in the elderly and urinary tract infection in acute care. *BMC geriatr*. 2006;6:15.

81. Saint S, Kaufman SR, Rogers MAM, Bakers PD, Boyko EJ, Lipsky BA. Risk factors for nosocomial urinary tract-related bacteremia: A case-control study. *Am J Infect Control*. 2006;34(7):401-407.

82. Srinivasan A, Karchmer T, Richards A, Song X, Perl TM. A prospective trial of a novel, silicone-based, silver-coated foley catheter for the prevention of nosocomial urinary tract infections. *Infect Control Hosp Epidemiol*. 2006;27(1):38-43.

83. Cardosi RJ, Cardosi RP, Grendys EC,Jr., Fiorica JV, Hoffman MS. Infectious urinary tract morbidity with prolonged bladder catheterization after radical hysterectomy... includes discussion. *Obstet Gynecol*. 2003;189(2):380-384.

84. Johansson I, Athlin E, Frykholm L, Bolinder H, Larsson G. Intermittent versus indwelling catheters for older patients with hip fractures. *J Clin Nurs*. 2002;11(5):651-656.

85. Hustinx WN, Mintjes-de Groot, Verkooyen RP, Verbrugh HA. Impact of concurrent antimicrobial therapy on catheter-associated urinary tract infection.[see comment]. *J Hosp Infect*. 1991;18(1):45-56.

86. Johnson JR, Roberts PL, Olsen RJ, Moyer KA, Stamm WE. Prevention of catheter-associated urinary tract infection with a silver oxide-coated urinary catheter: Clinical and microbiologic correlates. *J Infect Dis*. 1990;162(5):1145-1150.

87. Lima NL, Guerrant RL, Kaiser DL, Germanson T, Farr BM. A retrospective cohort study of nosocomial diarrhea as a risk factor for nosocomial infection. *J Infect Dis*. 1990;161(5):948-952.

88. Jacono JJ, Talamelli CL. Nosocomial urinary tract infection in catheterized patients. *Infect Control Can*. 1988;3(1):16-20.

89. Lanara V, Plati C, Paniara O, et al. The prevalence of urinary tract infection in patients related to type of drainage bag. *Scand J Caring Sci*. 1988;2(4):163-170.

90. Holliman R, Seal DV, Archer H, Doman S. Controlled trial of chemical disinfection of urinary drainage bags. reduction in hospital-acquired catheter-associated infection. *Br J Urol*. 1987;60(5):419-422.

91. Mulhall AB, Chapman RG, Crow RA. Bacteriuria during indwelling urethral catheterization. *J Hosp Infect*. 1988;11(3):253-262.

92. Pien FD, Landers JQ,Jr. Indwelling urinary catheter infections in small community hospital. role of urinary drainage bag. *Urology*. 1983;22(3):255-258.

93. Shapiro M, Simchen E, Izraeli S, Sacks TG. A multivariate analysis of risk factors for acquiring bacteriuria in patients with indwelling urinary catheters for longer than 24 hours. *Infect Control*. 1984;5(11):525-532.

94. Platt R, Polk BF, Murdock B, Rosner B. Risk factors for nosocomial urinary tract infection. *Am J Epidemiol*. 1986;124(6):977-985.

95. Burke JP, Larsen RA, Stevens LE. Nosocomial bacteriuria: Estimating the potential for prevention by closed sterile urinary drainage. *Infect Control*. 1986;7(2):96-99.

96. Saramma PP. Catheter-associated urinary tract infection: A follow-up study in prevention. *Nurs J India*. 1987;78(10):257-259.

97. Islam AK, Chapman J. Closed catheter drainage and urinary infection--a comparison of two methods of catheter drainage. *Br J Urol*. 1977;49(3):215-220.

98. Hartstein AI, Garber SB, Ward TT, Jones SR, Morthland VH. Nosocomial urinary tract infection: A prospective evaluation of 108 catheterized patients. *Infect Control*. 1981;2(5):380-386.

99. Garibaldi RA, Burke JP, Britt MR, Miller MA, Smith CB. Meatal colonization and catheter-associated bacteriuria. *N Engl J Med*. 1980;303(6):316-318.

100. Garibaldi RA, Burke JP, Dickman ML, Smith CB. Factors predisposing to bacteriuria during indwelling urethral catheterization. *N Engl J Med*. 1974;291(5):215-219.

101. Hirsh DD, Fainstein V, Musher DM. Do condom catheter collecting systems cause urinary tract infection? *JAMA*. 1979;242(4):340-341.

102. White MC, Ragland KE. Urinary catheter-related infections among home care patients. *J Wound Ostomy Continence Nurs*. 1995;22(6):286-290.

103. Wilde MH, Carrigan MJ. A chart audit of factors related to urine flow and urinary tract infection. *J Adv Nurs*. 2003;43(3):254-262.

104. Niel-Weise BS, van den Broek, P. J. Urinary catheter policies for short-term bladder drainage in adults. *Cochrane Libr*. 2006;4.

105. Shekelle PG, Morton SC, Clark KA, Pathak M, Vickrey BG. Systematic review of risk factors for urinary tract infection in adults with spinal cord dysfunction. *J Spinal Cord Med*. 1999;22(4):258-272.

106. Vickrey BG, Shekelle P, Morton S, Clark K, Pathak M, Kamberg C. Prevention and management of urinary tract infections in paralyzed persons. *Evid Rep Technol Assess*. 1999(6):1-3.

107. Branagan GW, Moran BJ. Published evidence favors the use of suprapubic catheters in pelvic colorectal surgery. *Dis Colon Rectum*. 2002;45(8):1104-1108.

108. McPhail MJ, Abu-Hilal M, Johnson CD. A meta-analysis comparing suprapubic and transurethral catheterization for bladder drainage after abdominal surgery. *Br J Surg*. 2006;93(9):1038-1044.

109. Saint S, Kaufman SR, Rogers MA, Baker PD, Ossenkop K, Lipsky BA. Condom versus indwelling urinary catheters: A randomized trial. *J Am Geriatr Soc*. 2006;54(7):1055-1061.

110. Michelson JD, Lotke PA, Steinberg ME. Urinary-bladder management after total joint-replacement surgery. *N Engl J Med*. 1988;319(6):321-326.

111. Tang MW, Kwok TC, Hui E, Woo J. Intermittent versus indwelling urinary catheterization in older female patients. *Maturitas*. 2006;53(3):274-281.

112. Turi MH, Hanif S, Fasih Q, Shaikh MA. Proportion of complications in patients practicing clean intermittent self-catheterization (CISC) vs indwelling catheter. *J Pak Med Assoc*. 2006;56(9):401-404.

113. Tangtrakul S, Taechaiya S, Suthutvoravut S, Linasmita V. Post-cesarean section urinary tract infection: A comparison between intermittent and indwelling catheterization. *J Med Assoc Thai*. 1994;77(5):244-248.

114. Skelly JM, Guyatt GH, Kalbfleisch R, Singer J, Winter L. Management of urinary retention after surgical repair of hip fracture. *Can Med Assoc J* . 1992;146(7):1185-1189.

115. Jannelli ML, Wu JM, Plunkett LW, Williams KS, Visco AG. A randomized controlled trial of clean intermittent self-catheterization versus suprapubic catheterization after urogynecologic surgery. *Am J Obstet Gynecol*. 2007;197(1).

116. Roberts K, Naik R. Catheterization options following radical surgery for cervical cancer. *Br J Nurs*. 2006;15(19):1038-1044.

117. Duffy LM, Cleary J, Ahern S, et al. Clean intermittent catheterization: Safe, cost-effective bladder management for male residents of VA nursing homes. *J Am Geriatr Soc*. 1995;43(8):865-870.

118. Moore KN, Burt J, Voaklander DC. Intermittent catheterization in the rehabilitation setting: A comparison of clean and sterile technique. *Clin Rehabil*. 2006;20(6):461-468.

119. Moore KN, Kelm M, Sinclair O, Cadrain G. Bacteriuria in intermittent catheterization users: The effect of sterile versus clean reused catheters. *Rehabil Nurs*. 1993;18(5):306-309.

120. Prieto-Fingerhut T, Banovac K, Lynne CM. A study comparing sterile and nonsterile urethral catheterization in patients with spinal cord injury. *Rehabil Nurs*. 1997;22(6):299-302.

121. Schlager TA, Clark M, Anderson S. Effect of a single-use sterile catheter for each void on the frequency of bacteriuria in children with neurogenic bladder on intermittent catheterization for bladder emptying. *Pediatrics*. 2001;108(4):E71.

122. Joseph C, Jacobson C, Strausbaugh L, Maxwell M, French M, Colling J. Sterile vs clean urinary catheterization. *J Am Geriatr Soc*. 1991;39(10):1042-1043.

123. Saint S, Lipsky BA, Baker PD, McDonald LL, Ossenkop K. Urinary catheters: What type do men and their nurses prefer? *J Am Geriatr Soc*. 1999;47(12):1453-1457.

124. Ritter MA, Faris PM, Keating EM. Urinary tract catheterization protocols following total joint arthroplasty. *Orthopedics*. 1989;12(8):1085-1087.

125. Oishi CS, Williams VJ, Hanson PB, Schneider JE, Colwell CW,Jr., Walker RH. Perioperative bladder management after primary total hip arthroplasty. *J Arthroplasty*. 1995;10(6):732-736.

126. Furuhata A, Ogawa K, Saito K, Yamaguchi T. Preoperative intermittent catheterization in patients with prostatic hypertrophy. *Clin Ther*. 1988;10 Spec No:47-51.

127. Alli MO, Singh B, Moodley J, Shaik AS. Prospective evaluation of combined suprapubic and urethral catheterization to urethral drainage alone for intraperitoneal bladder injuries. *Journal of Trauma-Injury Infection & Critical Care*. 2003;55(6):1152-1154.

128. Dunn TS, Figge J, Wolf D. A comparison of outcomes of transurethral versus suprapubic catheterization after burch cystourethropexy. *Int Urogynecol J Pelvic Floor Dysfunct*. 2005;16(1):60-2; discussion 62.

129. Dinneen MD, Wetter LA, May AR. Urethral strictures and aortic surgery. suprapubic rather than urethral catheters. *Eur J Vasc Surg*. 1990;4(5):535-538.

130. Horgan AF, Prasad B, Waldron DJ, O'Sullivan DC. Acute urinary retention. comparison of suprapubic and urethral catheterisation. *Br J Urol*. 1992;70(2):149-151.

131. Hofmeister FJ, Martens WE, Strebel RL. Foley catheter or suprapubic tube? *Obstet Gynecol*. 1970;107(5):767-779.

132. Van Nagell, JR, Penny RM, Roddick JW. Suprapubic bladder drainage following radical hysterectomy. *Obstet Gynecol*. 1972;113(6):849-850.

133. Verbrugh HA, Mintjes-de Groot, Andriesse R, Hamersma K, van Dijk A. Postoperative prophylaxis with norfloxacin in patients requiring bladder catheters. *Eur J Clin Microbiol Infect Dis*. 1988;7(4):490-494.

134. Noll F, Russe O, Kling E, Botel U, Schreiter F. Intermittent catheterisation versus percutaneous suprapubic cystostomy in the early management of traumatic spinal cord lesions. *Paraplegia*. 1988;26(1):4-9.

135. Weld KJ, Dmochowski RR, Foster HE,Jr. Effect of bladder management on urological complications in spinal cord injured patients. *J Urol*. 2000;163(3):768-772.

136. Lloyd LK, Kuhlemeier KV, Fine PR, Stover SL. Initial bladder management in spinal cord injury: Does it make a difference? *J Urol*. 1986;135(3):523-527.

137. Schumm K, Lam TB. Types of urethral catheters for management of short-term voiding problems in hospitalised adults.[update of cochrane database syst rev. 2004;(1):CD004013; PMID: 14974052]. *Cochrane Database Syst Rev*. 2008(2):004013.

138. Johnson JR, Kuskowski MA, Wilt TJ. Systematic review: Antimicrobial urinary catheters to prevent catheter-associated urinary tract infection in hospitalized patients. *Ann Intern Med*. 2006;144(2):116-126.

139. Niel-Weise BS, Arend SM, van den Broek, PJ. Is there evidence for recommending silver-coated urinary catheters in guidelines? *J Hosp Infect*. 2002;52(2):81-87.

140. van den Eijkel, E., Griffiths P. Catheter valves for indwelling urinary catheters: A systematic review. *Br J Community Nurs*. 2006;11(3):111-2, 114.

141. Crnich CJ, Drinka PJ. Does the composition of urinary catheters influence clinical outcomes and the results of research studies? *Infect Control Hosp Epidemiol*. 2007;28(1):102-103.

142. Reiche T, Lisby G, Jorgensen S, Christensen AB, Nordling J. A prospective, controlled, randomized study of the effect of a slow-release silver device on the frequency of urinary tract infection in newly catheterized patients. *BJU Int*. 2000;85(1):54-59.

143. Schaeffer AJ, Story KO, Johnson SM. Effect of silver oxide/trichloroisocyanuric acid antimicrobial urinary drainage system on catheter-associated bacteriuria. *J Urol*. 1988;139(1):69-73.

144. De Ridder, D. J., Everaert K, Fernandez LG, et al. Intermittent catheterisation with hydrophilic-coated catheters (SpeediCath) reduces the risk of clinical urinary tract infection in spinal cord injured patients: A prospective randomised parallel comparative trial. *Eur Urol*. 2005;48(6):991-995.

145. Cindolo L, Palmieri EA, Autorino R, Salzano L, Altieri V. Standard versus hydrophilic catheterization in the adjuvant treatment of patients with superficial bladder cancer. *Urol Int*. 2004;73(1):19-22.

146. Stensballe J, Looms D, Nielsen PN, Tvede M. Hydrophilic-coated catheters for intermittent catheterisation reduce urethral micro trauma: A prospective, randomised, participant-blinded, crossover study of three different types of catheters. *Eur Urol*. 2005;48(6):978-983.

147. Vapnek JM, Maynard FM, Kim J, Vapnek JM, Maynard FM, Kim J. A prospective randomized trial of the LoFric hydrophilic coated catheter versus conventional plastic catheter for clean intermittent catheterization. *J Urol*. 2003;169(3):994-998.

148. Monson T, Kunin CM. Evaluation of a polymer-coated indwelling catheter in prevention of infection. *J Urol*. 1974;111(2):220-222.

149. Shafik A. The electrified catheter. role in sterilizing urine and decreasing bacteriuria. *World J Urol*. 1993;11(3):183-185.

150. Leone M, Garnier F, Antonini F, Bimar MC, Albanese J, Martin C. Comparison of effectiveness of two urinary drainage systems in intensive care unit: A prospective, randomized clinical trial. *Intensive Care Med*. 2003;29(4):551-554.

151. Classen DC, Larsen RA, Burke JP, Stevens LE. Prevention of catheter-associated bacteriuria: Clinical trial of methods to block three known pathways of infection. *Am J Infect Control*. 1991;19(3):136-142.

152. al-Juburi AZ, Cicmanec J. New apparatus to reduce urinary drainage associated with urinary tract infections. *Urology*. 1989;33(2):97-101.

153. DeGroot-Kosolcharoen J, Guse R, Jones JM. Evaluation of a urinary catheter with a preconnected closed drainage bag. *Infect Control Hosp Epidemiol*. 1988;9(2):72-76.

154. Klarskov P, Bischoff N, Bremmelgaard A, Hald T. Catheter-associated bacteriuria. A controlled trial with bardex(TM) urinary drainage system. *Acta Obstet Gynecol Scand*. 1986;65(4):295-299.

155. Keys TF, Maker MD, Segura JW. Bacteriuria during closed urinary drainage: An evaluation of top-vented versus bag-vented systems. *J Urol*. 1979;122(1):49-51.

156. Platt R, Polk BF, Murdock B, Rosner B. Reduction of mortality associated with nosocomial urinary tract infection. *Lancet*. 1983;1(8330):893-897.

157. Monson TP, Macalalad FV, Hamman JW, Kunin CM. Evaluation of a vented drainage system in prevention of bacteriuria. *J Urol*. 1977;117(2):216-219.

158. Cleland V, Cox F, Berggren H, MacInnis MR. Prevention of bacteriuria in female patients with welling catheters. *Nurs Res*. 1971;20(4):309-318.

159. Seymour C. Audit of catheter-associated UTI using silver alloy-coated foley catheters. *Br J Nurs*. 2006;15(11):598-603.

160. Gentry H, Cope S. Using silver to reduce catheter-associated urinary tract infections. *Nurs Stand*. 2005;19(50):51-54.

161. Madeo M, Davies D, Johnson G, Owen E, Wadsworth P, Martin CR. The impact of using silver alloy urinary catheters in reducing the incidence of urinary tract infections in the critical care setting. *Br J Infect Control*. 2004;5(1):21-24.

162. Rupp ME, Fitzgerald T, Marion N, et al. Effect of silver-coated urinary catheters: Efficacy, cost-effectiveness, and antimicrobial resistance. *Am J Infect Control*. 2004;32(8):445-450.

163. Lai KK, Fontecchio SA, Lai KK, Fontecchio SA. Use of silver-hydrogel urinary catheters on the incidence of catheter-associated urinary tract infections in hospitalized patients. *Am J Infect Control*. 2002;30(4):221-225.

164. Akiyama H, Okamoto S. Prophylaxis of indwelling urethral catheter infection: Clinical experience with a modified foley catheter and drainage system. *J Urol*. 1979;121(1):40-42.

165. Bologna RA, Tu LM, Polansky M, Fraimow HD, Gordon DA, Whitmore KE. Hydrogel/silver ion-coated urinary catheter reduces nosocomial urinary tract infection rates in intensive care unit patients: A multicenter study. *Urology*. 1999;54(6):982-987.

166. Newton T, Still JM, Law E. A comparison of the effect of early insertion of standard latex and silver-impregnated latex foley catheters on urinary tract infections in burn patients. *Infect Control Hosp Epidemiol*. 2002;23(4):217-218.

167. Butler HK, Kunin CM. Evaluation of polymyxin catheter lubricant and impregnated catheters. *J Urol*. 1968;100(4):560-566.

168. Mooro H, Kamel M. Prevention of catheter fever by the use of furacin urethral inserts. *J Egypt Med Assoc*. 1966;49(8):550-553.

169. Pachler J, Frimodt-Moller C. A comparison of prelubricated hydrophilic and non-hydrophilic polyvinyl chloride catheters for urethral catheterization. *BJU Int*. 1999;83(7):767-769.

170. Chen TY, Ponsot Y, Carmel M, Bouffard N, Kennelly MJ, Tu LM. Multi-centre study of intraurethral valve-pump catheter in women with a hypocontractile or acontractile bladder. *Eur Urol*. 2005;48(4):628-633.

171. Danchaivijitr S, Chokeloidkaew S, Prutsachativuthi S, Trakulsomboon S. Should the open urinary drainage system be continued? *J Med Assoc Thai*. 1988;71 Suppl 3:14-18.

172. Wille JC, Blusse van Oud Alblas, A., Thewessen EA. Nosocomial catheter-associated bacteriuria: A clinical trial comparing two closed urinary drainage systems. *J Hosp Infect*. 1993;25(3):191-198.

173. Hardyck C, Petrinovich L. Reducing urinary tract infections in catheterized patients. *Ostomy Wound*. 1998;44(12):36-8, 40, 42-3.

174. Montagnino BA, Gonzales ET,Jr., Roth DR. Open catheter drainage after urethral surgery. *J Urol*. 1988;140(5):1250-1252.

175. Madeo M, Barr B, Owen E. A study to determine whether the use of a pre-connect urinary catheter system reduces the incidence of nosocomial urinary tract infections. *Br J Infect Control*. 2005;6(4):22-25.

176. Leone M, Garnier F, Dubuc M, Bimar MC, Martin C. Prevention of nosocomial urinary tract infection in ICU patients: Comparison of effectiveness of two urinary drainage systems. *Chest*. 2001;120(1):220-224.

177. Blenkharn JJ. Prevention of bacteriuria during urinary catheterization of patients in an intensive care unit: Evaluation of the 'ureofix 500' closed drainage system. *J Hosp Infect*. 1985;6(2):187-193.

178. Drach GW, Lacy SS, Cox CE,2nd. Prevention of catheter-induced post-prostatectomy infection. effects of systemic cephaloridine and local irrigation with neomycin-polymyxin through closed-drainage catheter system. *J Urol*. 1971;105(6):840-842.

179. Plowman R, Graves N, Esquivel J, Roberts JA. An economic model to assess the cost and benefits of the routine use of silver alloy coated urinary catheters to reduce the risk of urinary tract infections in catheterized patients. *J Hosp Infect*. 2001;48(1):33-42.

180. Platt R, Polk BF, Murdock B, Rosner B. Prevention of catheter-associated urinary tract infection: A cost-benefit analysis. *Infect Control Hosp Epidemiol*. 1989;10(2):60-64.

181. Saint S, Veenstra DL, Sullivan SD, Chenoweth C, Fendrick AM. The potential clinical and economic benefits of silver alloy urinary catheters in preventing urinary tract infection. *Arch Intern Med*. 2000;160(17):2670-2675.

182. Niel-Weise BS, van den Broek, P. J. Antibiotic policies for short-term catheter bladder drainage in adults. *Cochrane Libr*. 2006;4.

183. Niel-Weise BS, van den Broek, P. J. Urinary catheter policies for long-term bladder drainage. *Cochrane Libr*. 2006;4.

184. Griffiths R, Fernandez R. Strategies for the removal of short-term indwelling urethral catheters in adults. *Cochrane Libr*. 2007(2).

185. Esposito S, Noviello S, Leone S, Marvaso A, Drago L, Marchetti F, The LSG. A pilot study on prevention of catheter-related urinary tract infections with fluoroquinolones. *J Chemother*. 2006;18(5):494-501.

186. Wazait HD, Patel HR, Van Der Meulen, J. H. P., et al. A pilot randomized double-blind placebo-controlled trial on the use of antibiotics on urinary catheter removal to reduce the rate of urinary tract infection: The pitfalls of ciprofloxacin. *BJU Int*. 2004;94(7):1048-1050.

187. Lukkarinen O, Hellstrom P, Leppilahti M, Kontituri M, Tammela T. Antibiotic prophylaxis in patients with urinary retention undergoing transureteral prostatectomy. *Ann Chir Gynaecol*. 1997;86(3):239-242.

188. Lukkarinen O, Hellstrom P, Leppilahti M, Kontturi M, Tammela T. Prospective randomized open study between ciprofloxacin and a combination of sulfadiazine and trimethoprim in antibiotic prophylaxis in connection with transurethral prostatectomy. *Scand J Urol Nephrol*. 1996;30(1):33-36.

189. Vollaard EJ, Clasener HA, Zambon JV, Joosten HJ, van Griethuysen, AJ. Prevention of catheter-associated gram-negative bacilluria with norfloxacin by selective decontamination of the bowel and high urinary concentration. *J Antimicrob Chemother*. 1989;23(6):915-922.

190. Grabe M, Forsgren A, Hellsten S. A short antibiotic course given in conjunction with and after catheter removal consecutive to transurethral prostatic resection. *Scand J Urol Nephrol*. 1984;18(3):193-199.

191. Little PJ, Pearson S, Peddie BA, Greenslade NF, Utley WL. Amoxicillin in the prevention of catheter-induced urinary infection. *J Infect Dis*. 1974;129(0):suppl:S241-2.

192. Clarke SA, Samuel M, Boddy SA. Are prophylactic antibiotics necessary with clean intermittent catheterization? A randomized controlled trial. *J Pediatr Surg*. 2005;40(3):568-571.

193. Waites KB, Canupp KC, Armstrong S, DeVivo MJ. Effect of cranberry extract on bacteriuria and pyuria in persons with neurogenic bladder secondary to spinal cord injury. *J Spinal Cord Med*. 2004;27(1):35-40.

194. Firestein M, Mendelson G, Gronich D, Granot E, Ben-Israel J, Raz R. Can antibiotic use during routine replacement of long-term urinary catheter prevent bacteriuria? *Infectious Diseases in Clinical Practice*. 2001;10(3):133-135.

195. Schlager TA, Anderson S, Trudell J, Hendley JO. Effect of cranberry juice on bacteriuria in children with neurogenic bladder receiving intermittent catheterization. *J Pediatr*. 1999;135(6):698-702.

196. Schiotz HA, Guttu K. Value of urinary prophylaxis with methenamine in gynecologic surgery. *Acta Obstet Gynecol Scand*. 2002;81(8):743-746.

197. Tyreman NO, Andersson PO, Kroon L, Orstam S. Urinary tract infection after vaginal surgery. effect of prophylactic treatment with methenamine hippurate. *Acta Obstet Gynecol Scand*. 1986;65(7):731-733.

198. Pearman JW, Bailey M, Harper WE, Pearman JW, Bailey M, Harper WE. Comparison of the efficacy of "trisdine" and kanamycin-colistin bladder instillations in reducing bacteriuria during intermittent catheterisation of patients with acute spinal cord trauma. *Br J Urol*. 1988;62(2):140-144.

199. Pearman JW, Bailey M, Riley LP. Bladder instillations of trisdine compared with catheter introducer for reduction of bacteriuria during intermittent catheterisation of patients with acute spinal cord trauma. *Br J Urol*. 1991;67(5):483-490.

200. Adesanya AA, Osegbe DN, Amaku EO. The use of intermittent chlorhexidine bladder irrigation in the prevention of post-prostatectomy infective complications. *Int Urol Nephrol*. 1993;25(4):359-367.

201. Ball AJ, Carr TW, Gillespie WA, Kelly M, Simpson RA, Smith PJ. Bladder irrigation with chlorhexidine for the prevention of urinary infection after transurethral operations: A prospective controlled study.[see comment]. *J Urol*. 1987;138(3):491-494.

202. van den Broek, P. J., Daha TJ, Mouton RP. Bladder irrigation with povidone-iodine in prevention of urinary-tract infections associated with intermittent urethral catheterisation. *Lancet*. 1985;1(8428):563-565.

203. Savage JE, Phillips B, Lifshitz S, et al. Bacteriuria in closed bladder drainage versus continuous irrigation in patients undergoing intracavitary radium for treatment of gynecologic cancer. *Gynecol Oncol*. 1982;13(1):26-30.

204. Kirk D, Dunn M, Bullock DW, Mitchell JP, Hobbs SJ. Hibitane bladder irrigation in the prevention of catheter-associated urinary infection. *Br J Urol*. 1979;51(6):528-531.

205. Chamberlain G, Holt E. Automatic bladder irrigation after vaginal surgery. *Br J Urol*. 1975;47(6):641-643.

206. Clark LW. Neomycin in the prevention of postcatheterization bacteriuria. *Med J Aust*. 1973;1(21):1034-1036.

207. Washington EA. Instillation of 3% hydrogen peroxide or distilled vinegar in urethral catheter drainage bag to decrease catheter-associated bacteriuria. *Biol Res Nurs*. 2001;3(2):78-87.

208. Sweet DE, Goodpasture HC, Holl K, Smart S, Alexander H, Hedari A. Evaluation of H2O2 prophylaxis of bacteriuria in patients with long-term indwelling foley catheters: A randomized controlled study. *Infect Control*. 1985;6(7):263-266.

209. Thompson RL, Haley CE, Searcy MA, et al. Catheter-associated bacteriuria. failure to reduce attack rates using periodic instillations of a disinfectant into urinary drainage systems. *JAMA*. 1984;251(6):747-751.

210. Gillespie WA, Simpson RA, Jones JE, Nashef L, Teasdale C, Speller DC. Does the addition of disinfectant to urine drainage bags prevent infection in catheterised patients? *Lancet*. 1983;1(8332):1037-1039.

211. Maizels M, Schaeffer AJ. Decreased incidence of bacteriuria associated with periodic instillations of hydrogen peroxide into the urethral catheter drainage bag. *J Urol*. 1980;123(6):841-845.

212. Webster J, Hood RH, Burridge CA, Doidge ML, Phillips CM, George N. Water or antiseptic for periurethral cleaning before uninary catheterization: A randomized controlled trial. *Am J Infect Control*. 2001;29(6):389-394.

213. Bardwell TA. Comparing meatal cleansing. *Aust Nurs J*. 1999;7(2):30-31.

214. Sanderson PJ, Weissler S. A comparison of the effect of chlorhexidine antisepsis, soap and antibiotics on bacteriuria, perineal colonization and environmental contamination in spinally injured patients. *J Hosp Infect*. 1990;15(3):235-243.

215. Burke JP, Garibaldi RA, Britt MR, Jacobson JA, Conti M, Alling DW. Prevention of catheter-associated urinary tract infections. efficacy of daily meatal care regimens. *Am J Med*. 1981;70(3):655-658.

216. Ross PW, Smylie HG. A comparison of two regimes of catheterisation in the prophylaxis of urinary tract infection in gynaecological patients. *Br J Urol*. 1966;38(2):194-198.

217. Keerasuntonpong A, Thearawiboon W, Panthawanan A, et al. Incidence of urinary tract infections in patients with short-term indwelling urethral catheters: A comparison between a 3-day urinary drainage bag change and no change regimens. *Am J Infect Control*. 2003;31(1):9-12.

218. Dille CA, Kirchhoff KT, Sullivan JJ, Larson E. Increasing the wearing time of vinyl urinary drainage bags by decontamination with bleach. *Arch Phys Med Rehabil*. 1993;74(4):431-437.

219. Priefer BA, Duthie EH,Jr., Gambert SR. Frequency of urinary catheter change and clinical urinary tract infection. study in hospital-based, skilled nursing home. *Urology*. 1982;20(2):141-142.

220. Fera P, Glashan RQ, Bruschini H, Lelis MAS, Baretta MCC, Srougi M. Lubricated urethral catheters with lidocaine versus gentamycin for clean intermittent catheterization. *International Braz J Urol*. 2002;28(1):50-56.

221. Giannantoni A, Di Stasi SM., Scivoletto G, Virgili G, Dolci S, Porena M. Intermittent catheterization with a prelubricated catheter in spinal cord injured patients: A prospective randomized crossover study. *J Urol*. 2001;166(1):130-133.

222. Cohen A. A microbiological comparison of a povidone-iodine lubricating gel and a control as catheter lubricants. *J Hosp Infect*. 1985;6 Suppl A:155-161.

223. Kunin CM, Finkelberg Z. Evaluation of an intraurethral lubricating catheter in prevention of catheter-induced urinary tract infections. *J Urol*. 1971;106(6):928-930.

224. Darouiche RO, Goetz L, Kaldis T, Cerra-Stewart C, AlSharif A, Priebe M. Impact of StatLock securing device on symptomatic catheter-related urinary tract infection: A prospective, randomized, multicenter clinical trial. *Am J Infect Control*. 2006;34(9):555-560.

225. Darouiche RO, Thornby JI, Cerra-Stewart C, Donovan WH, Hull RA. Bacterial interference for prevention of urinary tract infection: A prospective, randomized, placebo-controlled, double-blind pilot trial. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America*. 2005;41(10):1531-1534.

226. Moore KN. Two methods for cleaning catheters used for intermittent catheterization: Sunlight(TM) liquid detergent and cetrimide 1:30 (savlon(TM)). *Canadian Journal of Rehabilitation*. 1990;4(2):87-92.

227. Alessandri F, Mistrangelo E, Lijoi D, Ferrero S, Ragni N. A prospective, randomized trial comparing immediate versus delayed catheter removal following hysterectomy. *Acta Obstet Gynecol Scand*. 2006;85(6):716-720.

228. Schiotz HA. Comparison of 1 and 3 days' transuretheral foley catheterization after vaginal plastic surgery. *International Urogynecology Journal*. 1995;6(3):158-161.

229. Polliack T, Bluvshtein V, Philo O, et al. Clinical and economic consequences of volume- or time-dependent intermittent catheterization in patients with spinal cord lesions and neuropathic bladder (structured abstract). *Spinal Cord*. 2005;43(10):615-619.

230. Anton HA, Chambers K, Clifton J, Tasaka J. Clinical utility of a portable ultrasound device in intermittent catheterization. *Archives of Physical Medicine & Rehabilitation*. 1998;79(2):172-175.

231. Moyad RH, Persky L. Vesical irrigation and urosepsis. *Invest Urol*. 1968;6(1):21-25.

232. Shohet I, Alagam M, Shafir R, Tsur H, Cohen B. Postoperative catheterization and prophylactic antimicrobials in children with hypospadias. *Urology*. 1983;22(4):391-393.

233. Anonymous. Evaluation of aseptic techniques and chlorhexidine on the rate of catheter-associated urinary-tract infection. southampton infection control team. *Lancet*. 1982;1(8263):89-91.

234. Cafferkey MT, Conneely B, Falkiner FR, Gillespie WA, Murphy D. Post-operative urinary infection and septicaemia in urology. *J Hosp Infect*. 1980;1(4):315-320.

235. Salomon J, Denys P, Merle C, et al. Prevention of urinary tract infection in spinal cord-injured patients: Safety and efficacy of a weekly oral cyclic antibiotic (WOCA) programme with a 2 year follow-up - an observational prospective study. *J Antimicrob Chemother*. 2006;57(4):784-788.

236. Wibell L, Scheynius A, Norrman K. Methenamine-hippurate and bacteriuria in the geriatric patient with a catheter. *Acta Med Scand*. 1980;207(6):469-473.

237. Kostiala AA, Nyren P, Jokinen EJ, Runeberg L. Prospective study on the appearance of antibody-coated bacteria in patients with an indwelling urinary catheter. *Nephron*. 1982;30(3):279-285.

238. Nyren P, Runeberg L, Kostiala AI, Renkonen OV, Roine R. Prophylactic methenamine hippurate or nitrofurantoin in patients with an indwelling urinary catheter. *Ann Clin Res*. 1981;13(1):16-21.

239. Norrman K, Wibell L. Treatment with methenamine hippurate in the patient with a catheter. *J Int Med Res*. 1976;4(2):115-117.

240. Pearman JW. The value of kanamycin-colistin bladder instillations in reducing bacteriuria during intermittent catheterisation of patients with acute spinal cord injury. *Br J Urol*. 1979;51(5):367-374.

241. Cox F, Smith RF, Elliott JP, Quinn EL. Neomycin-polymyxin prophylaxis of urinary-tract infection associated with indwelling catheters. *Antimicrob Agents Chemother*. 1966;6:165-168.

242. Thornton GF, Lytton B, Andriole VT. Bacteriuria during indwelling catheter drainage. effect of constant bladder rinse. *JAMA*. 1966;195(3):179-183.

243. Wongsatanapong W. Prevention of urinary tract infection by instillation of chlorhexidine into urinary drainage bags. *J Med Assoc Thai*. 1988;71 Suppl 3:19-21.

244. Sujka SK, Petrelli NJ, Herrera L. Incidence of urinary tract infections in patients requiring long-term catheterization after abdominoperineal resection for rectal carcinoma: Does betadine(TM) in the foley drainage bag make a difference? *European Journal of Surgical Oncology*. 1987;13(4):341-343.

245. Samuels P, Fisher P. The use of hydrogen peroxide in catheter drainage units. *AUAA J*. 1983;3(3):5-9.

246. Koskeroglu N, Durmaz G, Bahar M, Kural M, Yelken B. The role of meatal disinfection in preventing catheter-related bacteriuria in an intensive care unit: A pilot study in turkey. *J Hosp Infect*. 2004;56(3):236-238.

247. Matsumoto T, Sakumoto M, Takahashi K, Kumazawa J. Prevention of catheter-associated urinary tract infection by meatal disinfection. *Dermatology*. 1997;195 Suppl 2:73-77.

248. Stelling JD, Hale AM. Protocol for changing condom catheters in males with spinal cord injury. *SCI Nurs*. 1996;13(2):28-34.

249. Reid RI, Webster O, Pead PJ, Maskell R. Comparison of urine bag-changing regimens in elderly catheterised patients. *Lancet*. 1982;2(8301):754-756.

250. Kambal C, Chance J, Cope S, Beck J. Catheter-associated UTIs in patients after major gynaecological surgery. *Prof Nurse*. 2004;19(9):515-518.

251. Schiotz HA. Antiseptic catheter gel and urinary tract infection after short-term postoperative catheterization in women. *Arch Gynecol Obstet*. 1996;258(2):97-100.

252. Harrison LH. Comparison of a microbicidal povidone-iodine gel and a placebo gel as catheter lubricants. *J Urol*. 1980;124(3):347-349.

253. Chavigny KH. The use of polymixin B as a urethral lubricant to reduce the post-instrumental incidence of bacteriuria in females. an exploratory study. *Int J Nurs Stud*. 1975;12(1):33-42.

254. Nooyen RL. Prophylaxis of catheter-induced urinary tract infection in obstetric patients. *J Am Osteopath Assoc*. 1966;66(3):324-326.

255. Sims L, Ballard N. A comparison of two methods of catheter cleansing and storage used with clean intermittent catheterization. *Rehabil Nurs Res*. 1993;2(2):87-92.

256. Wald H, Epstein A, Kramer A. Extended use of indwelling urinary catheters in postoperative hip fracture patients. *Med Care*. 2005;43(10):1009-1017.

257. Wyatt TD, Timoney R. The effect of introducing a policy for catheter care on the catheter infection rate in a small hospital. *J Hosp Infect*. 1987;9(3):230-234.

258. Hoy WE, Kissel SM, Freeman RB, Sterling WA,Jr. Altered patterns of posttransplant urinary tract infections associated with perioperative antibiotics and curtailed catheterization. *Am J Kidney Dis*. 1985;6(4):212-216.

259. Pickard WG, Grundy DJ. A comparison of two methods of sterile urethral catheterisation in spinal cord injured adults. *Paraplegia*. 1996;34(1):30-33.

260. Jain M, Miller L, Belt D, King D, Berwick DM. Decline in ICU adverse events, nosocomial infections and cost through a quality improvement initiative focusing on teamwork and culture change. *Qual Saf Health Care*. 2006;15(4):235-239.

261. Reilly L, Sullivan P, Ninni S, Fochesto D, Williams K, Fetherman B. Reducing foley catheter device days in an intensive care unit: Using the evidence to change practice. *AACN Adv Crit Care*. 2006;17(3):272-283.

262. Verdier R, Parer S, Jean-Pierre H, Dujols P, Picot MC. Impact of an infection control program in an intensive care unit in france. *Infect Control Hosp Epidemiol*. 2006;27(1):60-66.

263. Topal J, Conklin S, Camp K, Morris V, Balcezak T, Herbert P. Prevention of nosocomial catheter-associated urinary tract infections through computerized feedback to physicians and a nurse-directed protocol. *Am J Med Qual*. 2005;20(3):121-126.

264. Misset B, Timsit JF, Dumay MF, et al. A continuous quality-improvement program reduces nosocomial infection rates in the ICU. *Intensive Care Med*. 2004;30(3):395-400.

265. Rosenthal VD, Guzman S, Safdar N. Effect of education and performance feedback on rates of catheter-associated urinary tract infection in intensive care units in argentina. *Infect Control Hosp Epidemiol*. 2004;25(1):47-50.

266. Berg DE, Hershow RC, Ramirez CA, Weinstein RA. Control of nosocomial infections in an intensive care unit in guatemala city. *Clin Infect Dis*. 1995;21(3):588-593.

267. Cools HJ, van der Meer JW. Infection control in a skilled nursing facility: A 6-year survey. *J Hosp Infect*. 1988;12(2):117-124.

268. Saint S, Kaufman SR, Thompson M, Rogers MA, Chenoweth CE. A reminder reduces urinary catheterization in hospitalized patients. *Jt Comm J Qual Patient Saf*. 2005;31(8):455-462.

269. Huang WC, Wann SR, Lin SL, et al. Catheter-associated urinary tract infections in intensive care units can be reduced by prompting physicians to remove unnecessary catheters. *Infect Control Hosp Epidemiol*. 2004;25(11):974-978.

270. Cornia PB, Amory JK, Fraser S, Saint S, Lipsky BA. Computer-based order entry decreases duration of indwelling urinary catheterization in hospitalized patients. *Am J Med*. 2003;114(5):404-407.

271. Jacobson JA, Burke JP, Kasworm E. Effect of bacteriologic monitoring of urinary catheters on recognition and treatment of hospital-acquired urinary tract infections. *Infect Control*. 1981;2(3):227-232.

272. Fendler EJ, Ali Y, Hammond BS, Lyons MK, Kelley MB, Vowell NA. The impact of alcohol and sanitizer use on infection rates in an extended care facility. *Am J Infect Control*. 2002;30(4):226-233.

273. Fryklund B, Haeggman S, Burman LG. Transmission of urinary bacterial strains between patients with indwelling catheters - nursing in the same room and in separate rooms compared. *J Hosp Infect*. 1997;36(2):147-153.

274. Wyndaele JJ, De Taeye N. Early intermittent self-catheterisation after spinal cord injury. *Paraplegia*. 1990;28(2):76-80.

275. Goetz AM, Kedzuf S, Wagener M, Muder RR. Feedback to nursing staff as an intervention to reduce catheter-associated urinary tract infections. *Am J Infect Control*. 1999;27(5):402-404.

276. Dumigan DG, Kohan CA, Reed CR, Jekel JF, Fikrig MK. Utilizing national nosocomial infection surveillance system data to improve urinary tract infection rates in three intensive-care units. *Clin Perform Qual Health Care*. 1998;6(4):172-178.

277. Mayes J, Bliss J, Griffiths P. Preventing blockage of long-term indwelling catheters in adults: Are citric acid solutions effective? *Br J Community Nurs*. 2003;8(4):172-175.

278. Muncie HL,Jr., Hoopes JM, Damron DJ, Tenney JH, Warren JW. Once-daily irrigation of long-term urethral catheters with normal saline. lack of benefit. *Arch Intern Med*. 1989;149(2):441-443.

279. Kunin CM, Chin QF, Chambers S. Formation of encrustations on indwelling urinary catheters in the elderly: A comparison of different types of catheter materials in "blockers" and "nonblockers". *J Urol*. 1987;138(4):899-902.

280. Burns JR, Gauthier JF. Prevention of urinary catheter incrustations by acetohydroxamic acid. *J Urol*. 1984;132(3):455-456.

281. Ruwaldt MM. Irrigation of indwelling urinary catheters. *Urology*. 1983;21(2):127-129.