Effectiveness of Preanalytic Practices on Contamination and Diagnostic Accuracy of Urine Cultures: a Laboratory Medicine Best Practices Systematic Review and Meta-analysis

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Effectiveness of Preanalytic Practices on Contamination and Diagnostic Accuracy of Urine Cultures: a Laboratory Medicine Best Practices Systematic Review and Meta-analysis

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SUMMARY

Background. Urinary tract infection (UTI) in the United States is the most common bacterial infection, and urine cultures often make up the largest portion of workload for a hospital-based microbiology laboratory. Appropriately managing the factors affecting the preanalytic phase of urine culture contributes significantly to the generation of meaningful culture results that ultimately affect patient diagnosis and management. Urine culture contamination can be reduced with proper techniques for urine collection, preservation, storage, and transport, the major factors affecting the preanalytic phase of urine culture.

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Objectives. The purposes of this review were to identify and evaluate preanalytic practices associated with urine specimens and to assess their impact on the accuracy of urine culture microbiology. Specific practices included collection methods for men, women, and children; preservation of urine samples in boric acid solutions; and the effect of refrigeration on stored urine. Practice efficacy and effectiveness were measured by two parameters: reduction of urine culture contamination and increased accuracy of patient diagnosis. The CDC Laboratory Medicine Best Practices (LMBP) initiative’s systematic review method for assessment of quality improvement (QI) practices was employed. Results were then translated into evidence-based practice guidelines.

Search strategy. A search of three electronic bibliographic databases (PubMed, SCOPUS, and CINAHL), as well as hand searching of bibliographies from relevant information sources, for English-language articles published between 1965 and 2014 was conducted.

Selection criteria. The search contained the following medical subject headings and key text words: urinary tract infections, UTI, urine/analysis, urine/microbiology, urinalysis, specimen handling, preservation, biological, preservation, boric acid, boric acid/borate, refrigeration, storage, time factors, transportation, transport time, time delay, time factor, timing, urine specimen collection, catheters, indwelling, urinary reservoirs, continent, urinary catheterization, intermittent urethral catheterization, clean voided, midstream, Foley, suprapubic, bacteriological techniques, and microbiological techniques.

Main results. Both boric acid and refrigeration adequately preserved urine specimens prior to their processing for up to 24 h. Urine held at room temperature for more than 4 h showed overgrowth of both clinically significant and contaminating microorganisms. The overall strength of this body of evidence, however, was rated as low. For urine specimens collected from women, there was no difference in rates of contamination for midstream urine specimens collected with or without cleansing. The overall strength of this evidence was rated as high. The levels of diagnostic accuracy of midstream urine collection with or without cleansing were similar, although the overall strength of this evidence was rated as low. For urine specimens collected from men, there was a reduction in contamination in favor of midstream clean-catch over first-void specimen collection. The strength of this evidence was rated as high. Only one study compared midstream collection with cleansing to midstream collection without cleansing. Results showed no difference in contamination between the two methods of collection. However, imprecision was due largely to the small event size. The diagnostic accuracy of midstream urine collection from men compared to straight catheterization or suprapubic aspiration was high. However, the overall strength of this body of evidence was rated as low. For urine specimens collected from children and infants, the evidence comparing contamination rates for midstream urine collection with cleansing, midstream collection without cleansing, sterile urine bag collection, and diaper collection pointed to larger reductions in the odds of contamination in favor of midstream collection with cleansing over the other methods of collection. This body of evidence was rated as high. The accuracy of diagnosis of urinary tract infection from midstream clean-catch urine specimens, sterile urine bag specimens, or diaper specimens compared to straight catheterization or suprapubic aspiration was varied.

Authors’ conclusions. No recommendation for or against is made for delayed processing of urine stored at room temperature, refrigerated, or preserved in boric acid. This does not preclude the use of refrigeration or chemical preservatives in clinical practice. It does indicate, however, that more systematic studies evaluating the utility of these measures are needed. If noninvasive collection is being considered for women, midstream collection with cleansing is recommended, but no recommendation for or against is made for midstream collection without cleansing. If noninvasive collection is being considered for men, midstream collection with cleansing is recommended and collection of first-void urine is not recommended. No recommendation for or against is made for collection of midstream urine without cleansing. If noninvasive collection is being considered for children, midstream collection with cleansing is recommended and collection in sterile urine bags, from diapers, or midstream without cleansing is not recommended. Whether midstream collection with cleansing can be routinely used in place of catheterization or suprapubic aspiration is unclear. The data suggest that midstream collection with cleansing is accurate for the diagnosis of urinary tract infections in infants and children and has higher average accuracy than sterile urine bag collection (data for diaper collection were lacking); however, the overall strength of evidence was low, as multivariate modeling could not be performed, and thus no recommendation for or against can be made.

INTRODUCTION

The most common infection occurring in the United States is urinary tract infection (UTI), accounting for nearly 7 million office visits, 1 million emergency room visits, and 100,000 hospitalizations per year (1, 2). Significantly more women than men are likely to experience UTIs, with 1 in 3 women having at least 1 episode of UTI necessitating treatment with antibiotics by the age of 24 (3). Nearly half of all women will experience at least one UTI during their lifetime (3–6). An increased risk of UTI occurs in certain population subgroups, including infants (7), pregnant women (8), the elderly (9), patients with spinal cord injuries and/or catheters (10), patients with diabetes (11) or multiple sclerosis (12), and patients with AIDS/human immunodeficiency virus (13, 14). The most common nosocomial infection is catheter-associated UTI, with over a million cases in hospital and nursing home patients every year (15). Increasing duration of catheterization increases the risk of infection (16). Urinary tract infections are the second-most-common infection in noninstitutionalized elderly populations and account for nearly 25% of all infections (9). The financial impact of UTIs is significant, with costs of up to $2 billion per year (17).

While many uncomplicated UTIs in outpatients are diagnosed clinically, the diagnosis of recurrent or complicated UTI is commonly achieved by testing urine specimens for the presence of microorganisms. As a result, urine cultures often make up the largest portion of the workloads of clinical microbiology laboratories (18). The appropriate management of components of the preanalytic phase of urine culture, namely, collection, preservation, and storage of urine specimens, has an important influence
on the generation of meaningful culture results, which ultimately affects patient diagnosis and management (19).

Quality Gap: Factors Associated with the Preanalytic Phase of Urine Culture

The major goal of proper specimen management is to ensure that specimen quality is maintained during collection and transport (20). Urine specimens can easily become contaminated with periurethral, epidermal, perianal, and vaginal flora. This contamination can be reduced with proper attention to techniques for urine collection, transport, preservation, and storage, the major components of the preanalytic phase of urine culture. A Q-Probe study conducted by the College of American Pathologists in 1998 (21) and again in 2008 (22) examined the frequency of urine culture contamination (defined as more than two isolates in quantities greater than 10,000 CFU/ml) and associated facility practices of urine collection and specimen management. Contamination rates of 41.7% (low-performance facilities), 15% (median performers), and 0.8% (high performers) correspond to the 10th, 50th, and 90th percentiles of facilities, respectively (22). Contamination rates had no correlation to collection site, use of collection kits, preservatives, or thermally insulated transport containers. However, contamination rates were substantially affected by postcollection processing, especially refrigeration of the specimen. Also, collection instructions given in the outpatient setting had a statistically significant impact on contamination rates in some cases. Based on the similarities of overall contamination rates between the two Q-Probe studies, the authors concluded that no significant progress in reducing urine culture contamination during the intervening years had been made (22). This may be a reflection of the inherent limitations of the Q-Probe methodology, which is based on one-time quality assessments dependent on the gathering of current data from large numbers of laboratories in order to establish provisional benchmarks for systematic quality improvement efforts. Many of these indicators are based primarily on self-reported surveys rather than on evidence-based scientific study design and/or adequately specified, standardized, and consistently implemented data collection methods. Nonetheless, it is not cost-effective for laboratories to continue to waste valuable resources on the work-up of contaminated urine cultures (23). Furthermore, inappropriate reporting of contaminated urine cultures by the laboratory can result in patients receiving suboptimal or unnecessary therapy, producing poor patient outcomes and higher cost (18).

To address this important quality gap and its consequences, this research identified and evaluated practices associated with the collection, preservation, and storage of urine specimens for culture and their impact on the accuracy of urine culture microbiology. Rating criteria were used for evaluating these practices. Specific practices examined included collection methods for men, women, children, and infants; preservation of urine samples in boric acid solutions; and the effect of refrigeration on urine storage. The evidence supporting these practices for minimizing contaminated urine cultures and the impact on the accuracy of patient diagnosis were evaluated by applying the LMBP initiative’s systematic review methods for quality improvement practices and by translating the results into evidence-based guidance (24). The methodology has recently been used to evaluate preanalytical practices for reducing blood culture contamination (25) and blood sample hemolysis (26).

A-6 CYCLE FOR SYSTEMATIC REVIEW

The CDC’s LMBP “A-6 Cycle” systematic review methods for evaluating quality improvement practices was used for conducting this review. The methodology, reported in detail elsewhere (24), is derived from previously validated methods. It is designed to assess the results of studies of practice effectiveness that lead to best-practice recommendations that are evidence based. Using this method, a review coordinator (author Mark T. LaRocco) and individuals trained to apply the LMBP methods (authors Alice S. Weissfeld and Elizabeth K. Leibach) conducted the systematic review with guidance from an expert panel. The expert panelists (authors Nancy E. Cornish, Colleen S. Kraft, Vickie Baselski, Robert L. Sautter, Edward J. Peterson, and Debra Rodahl) were chosen based on their breadth of experience and perspective in clinical microbiology and laboratory management. A description of their scientific credentials and professional affiliations can be found in the author biography section. Lastly, the team was supported by a statistician with expertise in evidence review methodologies and meta-analysis (author Jacob Franek). The expert panel reviewed the results of the evidence review and drafted the evidence-based best-practice recommendations. The recommendations were then approved by the LMBP Workgroup, consisting of 13 invited members with broad expertise in laboratory medicine, clinical practice, health services research, and health policy, as well as one [ex officio] representative from the Centers for Medicare and Medicaid Services. A list of the members of the LMBP Workgroup is provided in Appendix 1.

Review Question, Analytical Framework, and Search Strategy

The review question addressed by this analytical review was as follows: “Are there preanalytic practices related to the collection, preservation, transport, and storage of urine for microbiological culture that improve the diagnosis and management of patients with urinary tract infection?” Components of the preanalytic phase of urine culture were studied in the context of an analytical framework for factors affecting specimen contamination and diagnostic accuracy, depicted in Fig. 1. The population, intervention, comparison, and outcome (PICO) elements are as follows.

- “Population” is any patients who have urine cultures collected.
- “Intervention” is clinical practice.
- “Comparison” is made of
  - immediate versus delayed processing of urine held at room temperature,
  - immediate versus delayed processing of refrigerated urine or urine preserved in boric acid,
  - midstream clean-catch collection of urine without cleansing versus with cleansing (men and women),
  - midstream clean-catch collection of urine without cleansing versus with cleansing versus collection with a sterile urine bag versus diaper collection for infants and children.
- “Outcomes” are the results of determining the contamination rate and the diagnostic accuracy of urine culture.
Specific practices involving the preanalytic phase of urine culture covered in this evidence-based review were addressed by asking the following eight clinical questions.

1. What is the difference in colony counts when comparing immediate versus delayed processing of fresh urine stored at room temperature after collection?
2. What is the difference in colony counts when comparing immediate versus delayed processing of urine kept refrigerated or preserved in boric acid?
3. What is the difference in contamination rates between midstream urine collected with cleansing versus without cleansing in women being tested for a UTI?
4. What is the diagnostic accuracy of midstream urine collected with or without cleansing compared to bladder catheterization for the diagnosis of UTI in women?
5. What is the difference in contamination rates between midstream collection, with or without cleansing, and first-void collection in men?
6. What is the diagnostic accuracy of midstream urine collected, with or without cleansing, compared to that of bladder catheterization or suprapubic aspiration for the diagnosis of UTI in men?
7. What are the differences in contamination rates between midstream urine collection, with or without cleansing, and sterile urine bag or diaper collection in children?
8. What is the diagnostic accuracy of midstream clean-catch, sterile urine bag, or diaper collection compared with that of suprapubic aspiration or catheterization for the diagnosis of UTI in children?

The search for studies of practice effectiveness was conducted to identify those with measurable outcomes collected to the rigor of review requirements. With input from the expert panel and assistance of a research librarian at the Jesse Jones Library at the Texas Medical Center in Houston, TX, a literature search strategy and set of terms were developed. A search of three electronic bibliographic databases (PubMed, SCOPUS, and CINAHL) for English-language articles published between 1965 and 2014 was conducted. In addition, hand searching of bibliographies from relevant information sources was performed. All search results were catalogued and maintained using a Web-based, commercial reference software package (RefWorks; ProQuest LLC, Ann Arbor, MI). Finally, solicitation of unpublished quality improvement studies was attempted by posting requests for data on both the Laboratory Medicine Best Practices website (https://www.cdc.gov/futurelhabmedicine/) and two listservs supported by the American Society for Microbiology: clinmicronet (http://www.asm.org/index.php/online-community-groups/listservs) and DivCNets (http://www.asm.org/division/c/divcnet.htm).

The search contained the following medical subject headings (MESH) and key text words: “urinary tract infections” (MESH) OR UTI (text word) OR urinary tract infect* (text word); “urine/analysis” (major) OR “urine/microbiology” (major) OR “urinalysis” (MESH); “specimen handling” (major); “preservation, biological” (MESH) OR preservation, biological (text word) OR “boric acids” (MESH) OR boric acid (text word) OR boric acid/borate (text word) OR boric acids (text word) OR “refrigeration” (MESH) OR refrigeration (text word) OR preserve* (text word); storage (text word); “time factors” (MESH) OR “transportation” (MESH) OR transport time (text word) OR delay (text word) OR time delay (text word) OR time factor (text word) OR timing (text word); “urine specimen collection” (MESH) OR urine specimen collection (text word) OR “catheters, indwelling” (MESH) OR catheters, indwelling (text word) OR “urinary reservoirs, continent” (MESH) OR urinary reservoirs, continent (text word) OR “urinary catheterization” (MESH) OR urinary catheterization (text word) OR “intermittent urethral catheterization” (MESH).
OR intermittent urethral catheterization (text word) OR clean voided (text word) OR midstream (text word) OR suprapubic (text word); and “bacteriological techniques” (MESH) OR bacteriological technique (text word) OR microbiological techniques (text word) OR “microbiological techniques” (MESH) OR microbiological technique (text word) OR microbiological techniques (text word).

Titles and abstracts were initially screened by the review coordinator, with assistance from the expert panel when necessary, to select studies for a full review. A study was included if it was considered likely to provide valid and useful information and met the PICO criteria previously discussed. Specifically, these inclusion criteria required that a study (i) address a defined population/definable group of patients, (ii) evaluate a specific intervention/practice included in this review, (iii) describe at least one finding for a relevant outcome measure (percent contamination, diagnostic accuracy) reproducible in comparable settings, and (iv) present results in a format which was useful for statistical analysis. Studies failing to meet the inclusion criteria (not considered to report a relevant practice, did not include a practice of interest, or did not present an outcome measure of interest) were excluded from further review.

Studies that cleared this initial screening were then abstracted and evaluated by the expert panel. For eligible studies, information on study characteristics, interventions, outcome measures, and findings of the study was extracted using a standardized form and assigned a quality rating derived from points awarded for meeting quality criteria. Individual quality ratings were based on four dimensions: study quality, practice effectiveness, defined outcome measure(s), and findings/results. The objective for rating individual study quality was to judge whether sufficient evidence of practice effectiveness was available to support inclusion in an overall body of evidence for evaluation of a best-practice recommendation (that is, a practice likely to be effective in improving one or more outcomes of interest in comparison to other commonly used practices).

The four study quality dimensions were rated separately, with a rating score assigned up to the maximum for a given dimension. The rating scores for all four dimensions were added to reach a single summary score reflecting overall study quality. A total of 10 points were available for each study. Reviewers assigned one of three quality ratings to each study: good (8 to 10 points), fair (5 to 7 points), or poor (4 points or less). Each study was reviewed and rated by two expert panel members to minimize subjectivity and bias. Any study ranked as poor by one reviewer but good by the second reviewer was assigned to a third expert panel member for resolution. More detail on the rating process of individual studies can be found elsewhere (24–26). Studies that did not meet a study quality rating of fair or good were excluded from further consideration. Data from published studies that passed a full review were transformed to a standardized, common metric according to LMBP methods (24). Summary data and quality scores for each publication included in this evidence-based review can be found in Appendix 3 below.

The study quality ratings and results from the individual studies for each clinical question were aggregated into bodies of evidence. The consistency of effects and patterns of effects across studies and the rating of overall strength of the body of evidence (high, moderate, low, suggestive, and insufficient) were based on both qualitative and quantitative analyses. Estimates of effect and the strength of the body of evidence were then used to translate results into one of three evidence-based recommendations (recommend, no recommendation for or against, recommend against). The ratings criteria are described in greater detail elsewhere (24).

While recommendations are based on the entire body of evidence, meta-analyses to generate summary estimates of effect were undertaken for outcomes that provided sufficient data for measurements of diagnostic accuracy and contamination, i.e., proportions of specimens containing periurethral, perianal, epidermal, or vaginal flora. For the outcome of contamination proportion, summary odds ratios were calculated using Mantel-Haenszel methods in a random-effects model performed using Review Manager (RevMan) software version 5.0 (2008; The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, DK). A contamination event was defined according to how individual studies defined contamination because definitions varied between studies. Wherever possible, contamination proportions were determined for the entire test population rather than a subset population (such as only among those individuals that tested negative for urinary tract infection). The I² statistic, which describes the percentage of variability in effects estimates due to statistical heterogeneity rather than sampling error, was used to assess between-study heterogeneity. For the outcomes of diagnostic accuracy, it was planned that point estimates of sensitivity and specificity would be summarized using the bivariate model when similar cutoff points were used; however, all models failed to converge due to a too-small number of study or sample sizes. Similarly, hierarchical summary receiver operator characteristic curves (HSROC) could not be generated because these models too failed to converge. Solutions for failure of convergence, including removing individual studies, were explored but did not improve convergence. Meta-analysis of diagnostic accuracy outcomes and curve fitting were not pursued further given the limitations of univariate methods. All work on summarizing diagnostic accuracy outcomes was performed using SAS software version 9.2 (2008; SAS Institute Inc., Cary, NC, USA) and the MetaDAS macro, version 1.3 (27). Significant growth (i.e., a positive sample) was defined according to how each individual study defined significant growth because cutoff points tended to vary among studies. All other growth, including contamination and no growth, were considered nonsignificant growth (i.e., a negative sample), as this most closely reflects actual clinical practice. Two-by-two tables were used to determine sensitivity and specificity, and exact 95% confidence intervals were calculated.

Search Results

Search results produced 5,092 unique documents that were initially screened for eligibility to contribute to evidence of effectiveness for practices defined by the eight clinical questions posed (storage and preservation of urine, collection of urine from women, collection of urine from men, and collection of urine from infants and children). There was no response to requests for unpublished data. The reduction of studies through the screening process is detailed in Fig. 2. Initial screening for topic relevance eliminated 4,917 studies. From the remaining 171 studies, 124 were eliminated for not meeting
the inclusion criteria (i.e., having elements potentially relevant to at least one topic area review question, reporting practices that are in use and available for adoption, reporting practices reproducible in other comparable settings, and addressing a defined population/definable group of patients). Forty-seven studies met the criteria for inclusion and were subjected to full abstraction and quality scoring. After an additional 12 studies were excluded because of insufficient quality scores, the remaining 35 were included in the statistical analysis: 10 studies on storage and preservation, 8 studies on collection from women, 3 studies on collection from men, and 14 studies on collection from infants and children.

**STORAGE AND PRESERVATION OF URINE**

Summary information on the 10 published studies comprising the body of evidence for the clinical questions on the storage and preservation of urine is presented in Tables 1 and 2. The publication dates for these studies range from 1969 (28) to 1999 (29). All studies were given a “fair” quality rating. Three studies examined the effect of prolonged storage of clean-catch urine samples.

### TABLE 1 Body-of-evidence table for clinical question 1, namely, "what is the difference in colony counts when comparing immediate and delayed (≥4 h) processing of fresh urine stored at room temperature after collection?"

<table>
<thead>
<tr>
<th>Study (reference), quality rating</th>
<th>Samples</th>
<th>Setting</th>
<th>Time period</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hindman et al. (30), fair</td>
<td>100 random samples of urine were cultured within 2 h of collection and then again after 2 h and 4 h of storage at room temp.</td>
<td>Clinical Microbiology Laboratory, Hartford Hospital, Hartford, CT</td>
<td>Not given</td>
<td>SG was defined as any growth of &gt;10^5 CFU/ml. All other growth was considered NSG. Upon receipt, there were 47 SG and 53 NSG specimens. After 4 h, there were 51 SG and 49 NSG specimens.</td>
</tr>
<tr>
<td>Lum and Meers (31), fair</td>
<td>175 clean-catch urine samples were divided, and one portion was treated with boric acid at a concn of 20 g/liter and the other held in a sterile tube. All samples were cultured upon receipt in the laboratory and again after 4 h, 24 h, and 48 h of storage at room temp.</td>
<td>Microbiology Department, University of Singapore, Kent Ridge, Singapore</td>
<td>6 mo</td>
<td>SG was defined as ≥10^5 CFU/ml of 1 or 2 species. All other growth was considered NSG. Upon receipt, there were 38 SG and 137 NSG specimens. At 4 h, there were 42 SG and 133 NSG specimens. At 24 h, there were 90 SG and 82 NSG specimens. At 48 h, there were 109 SG and 66 NSG specimens.</td>
</tr>
<tr>
<td>Porter and Brodie (28), fair</td>
<td>130 midstream urine specimens that had been collected in sterile tubes and kept at room temp or preserved with 0.5 g of boric acid were mailed to a laboratory and cultured immediately upon receipt (avg delay of 24 h before receipt) and again at 72 h after receipt.</td>
<td>Laboratory, City Hospital, Aberdeen, Scotland</td>
<td>Not given</td>
<td>SG was defined as any growth of &gt;10^5 CFU/ml. All other growth was considered NSG. Upon receipt, there were 40 SG and 90 NSG specimens. After 72 h, there were 93 SG and 37 NSG specimens.</td>
</tr>
</tbody>
</table>

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*a* SG, significant growth; NSG, nonsignificant growth.

*FIG 2 Systematic review flow diagram.*
TABLE 2 Body-of-evidence table for clinical question 2, namely, "what is the difference in colony counts when comparing immediate and delayed (≥24 h) processing of urine kept refrigerated or preserved in boric acid?"

<table>
<thead>
<tr>
<th>Study (reference), quality rating</th>
<th>Samples Setting</th>
<th>Time period</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gillespie et al. (29), fair</td>
<td>792 midstream specimens of urine from 792 general practice patients were received preserved in 18 g/liter BA. Samples were cultured within 8 h of laboratory receipt (immediate) and again after overnight storage at room temp (delayed).</td>
<td>Clinical Microbiology Laboratory, Western General Hospital, Edinburgh, United Kingdom</td>
<td>Not given</td>
</tr>
<tr>
<td>Guenther and Washington (33), fair</td>
<td>Midstream clean-catch or catheterized urine was collected from patients suspected of having UTIs. Split samples were transported to the laboratory in either refrigerated sterile tubes or in Becton, Dickinson urine culture kit tubes containing GBF. Sterile urine was cultured immediately upon receipt (immediate), and preserved specimens were cultured again after storage for 24 and 48 h at room temp (delayed).</td>
<td>Clinical Microbiology Laboratory, Mayo Clinic, Rochester, MN</td>
<td>Not given</td>
</tr>
<tr>
<td>Hubbard et al. (34), fair</td>
<td>A total of 100 random clinical urine specimens were divided and tested to compare urine preserved in Becton, Dickinson urine culture kit tubes containing GBF with refrigerated urine. Each pair was cultured at 0, 5, and 24 h.</td>
<td>Clinical Microbiology Laboratory, University of Michigan Medical Center, Ann Arbor, MI</td>
<td>Not given</td>
</tr>
<tr>
<td>Lauer et al. (35), fair</td>
<td>1,000 urine specimens from children and adults suspected of having UTIs were received by the laboratory. Upon receipt, specimens were refrigerated until they could be cultured. Specimens were then cultured immediately (immediate) or split into 2 samples: 1 refrigerated for 18–24 h (delayed) and 1 preserved with Becton, Dickinson urine culture kit tubes of GBF for 18–24 h (delayed) and stored at room temp.</td>
<td>Clinical Microbiology Laboratory, Colorado General Hospital, Denver, CO</td>
<td>Not given</td>
</tr>
<tr>
<td>Lum and Meers (31), fair</td>
<td>175 clean-catch urine samples obtained from various hospital wards and clinics were divided; 1 portion was treated with BA at a concn of 20 g/liter and the other held in a sterile tube. All samples were cultured upon receipt in the laboratory (immediate) and again after 4 h, 24 h, and 48 h of storage at room temp (delayed).</td>
<td>Microbiology Department, University of Singapore, Kent Ridge, Singapore</td>
<td>6 mo</td>
</tr>
<tr>
<td>Porter and Brodie (28), fair</td>
<td>130 midstream urine specimens were collected in sterile tubes kept at room temp or preserved with 0.5 g of boric acid, mailed to the laboratory, and cultured immediately upon receipt, with an avg delay of 24 h before receipt (immediate). They were cultured again after 2 h of storage at room temp (delay).</td>
<td>Laboratory, City Hospital, Aberdeen, Scotland</td>
<td>Not given</td>
</tr>
<tr>
<td>Southern and Luttrell (36), fair</td>
<td>312 midstream urine specimens were transported to the laboratory in either sterile tubes or Becton, Dickinson urine culture kit tubes containing GBF. All specimens were tested immediately upon receipt. If not tested within 20 min, specimens were refrigerated. Preserved specimens were retested after being held for 24 h at room temp.</td>
<td>Parkland Memorial Hospital, Dallas, TX</td>
<td>Not given</td>
</tr>
<tr>
<td>Weinstein (37), fair</td>
<td>869 urine specimens obtained from inpatients in 3 medical units were split and transported to the laboratory in either sterile tubes, Becton, Dickinson urine culture kit tubes containing GBF, or Becton, Dickinson Vacutainer tubes containing SBF. All specimens were cultured immediately upon receipt (immediate) and then again after being held for 24 h at either room temp (BA tubes) or under refrigeration (sterile tubes).</td>
<td>Middlesex General University Hospital, New Brunswick, NJ</td>
<td>6 mo</td>
</tr>
<tr>
<td>Wright et al. (32), fair</td>
<td>Fresh urine specimens received by the laboratory were preserved in 3 formulations of BA: 5.5% pure BA, BA in Becton, Dickinson urine culture kit tubes containing GBF, and BA in Becton, Dickinson Vacutainer tubes containing SBF. They were tested for the presence of bacteria by culture and by various screening methods for assessing bacteriuria. Samples of fresh urine were tested upon receipt by the laboratory (immediate), and preserved samples were tested after being held for 24 h at room temp (delay).</td>
<td>Department of Pathology, University of Utah Medical Center, Salt Lake City, UT</td>
<td>Not given</td>
</tr>
</tbody>
</table>

a BA, boric acid; GBF, glycerol-boric acid-sodium formate; SBF, sorbitol-boric acid-sodium formate; SG, significant growth; NSG, nonsignificant growth.
urine at room temperature by culturing samples of urine immediately upon receipt and then again after 2 h and 4 h (30), after 4 h, 24 h, and 48 h (31), or after 24 h and 72 h (28) of storage at room temperature. Nine studies tested the effect of preserving urine in boric acid for 24 h on colony counts and compared the results with the results of immediate culture. Several different boric acid formulations were used, including boric acid alone (29, 31, 32), glycerol-boric acid-sodium formate (32–37), and sorbitol-boric acid-sodium formate (32, 37). The length of delay of culture while samples were preserved in boric acid was assessed at various time points across studies, but 24 h was chosen for analysis as it was the most common endpoint. Three studies examined the effect of 24-h refrigeration of urine samples on changes in colony counts from those of immediate culture (33, 35, 37). The majority of studies used clean-catch midstream urine samples, although collection methods were undefined in five studies (30, 32, 34, 35, 37). Growth was defined as either “significant” or “nonsignificant.” The definitions of significant growth varied among studies, but in general, a threshold of $>10^5$ CFU/ml of one or two species of bacteria was used.

**Body-of-Evidence Qualitative Analysis**

The difference in colony counts when immediate and delayed processing of urine specimens stored at room temperature were compared is shown in Table 3. Data from three observational studies (28, 30, 31) found a moderate increase (approximately 10%) in colony counts after 4 h of storage at room temperature and a large increase (>135%) in colony counts after storage for 24 h or more. The effect of delayed culture on urine specimens kept refrigerated or preserved in solutions of boric acid is shown in Tables 4, 5, and 6. Data from three observational studies (29, 33, 35) found 73 to 93% positive agreement (sensitivity) and 96 to 100% negative agreement (specificity) between the results of immediate culture and after a 24-h delay with specimens preserved in boric acid. Data from one study (35) found 93% positive agreement and 100% negative agreement between specimens cultured immediately upon receipt versus after a 24-h delay with refrigeration (Table 4). Colony counts in urine samples either refrigerated or chemically preserved showed similar results. Five studies (31, 32, 34, 37, 38) showed that urine samples preserved in boric acid solutions for 24 h (Table 5) or refrigerated for 24 h (Table 6) had only minor changes in the numbers of cultures with either significant or nonsignificant growth.

These data suggest that both boric acid and refrigeration adequately preserve urine specimens prior to their processing for up to 24 h. Furthermore, the results suggest that urine held at room temperature for more than 4 h should not be processed due to overgrowth of both clinically significant and contaminating microorganisms. Based on statistical analysis of the data, however, the overall strength of this body of evidence was rated as low.

**COLLECTION OF URINE FROM WOMEN**

Summary information on the eight published studies comprising the body of evidence for the clinical questions on contamination rates and the diagnostic accuracy of midstream urine collection from adult females is presented in Tables 7 and 8. Three studies (39–41) were given a quality rating of “good,” and five studies (38, 42–45) were rated as “fair.” Five studies (38–40, 42, 43) examined the impact of perineal cleansing on contamination and are summarized in Table 7. Patient settings included a clinic for adolescents (38), a general practice (38), an antenatal ambulatory-care clinic (39, 43), and a health center for teenagers (40). Definitions of contamination varied among studies and included any growth of normal vaginal flora and/or small quantities (<2,000 CFU/ml) of pathogenic bacteria (38), the presence of epithelial cells (42), mixed growth in quantities of $>10^5$ CFU/ml (39) or at any quantity (43), and growth of any nonpathogen or pathogen in quantities of $<10^5$ CFU/ml (43) or $<10^4$ CFU/ml (40).

Three studies (41, 44, 45) examined the diagnostic accuracy of midstream urine collection with or without cleansing, with straight urinary catheterization as the reference standard (Table 8). Patient populations in these studies included women presenting to an emergency department (41) or ambulatory clinic (44) or admitted to a general medical ward (45). In two studies (43, 44), each patient had urine collected by midstream collection with cleansing, followed by a second collection by urinary catheterization. In the third study (46), no cleansing was performed prior to midstream collection.

**Body-of-Evidence Qualitative Analysis**

The evidence examining the impact of perineal cleansing on contamination of midstream urine specimens collected from females is depicted in Fig. 3. Data from four observational studies (38, 40, 42, 43) and one randomized control trial (39) found no difference

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**TABLE 3** Difference in colony counts when results of immediate and delayed plating of fresh urine stored at room temperature were compared

<table>
<thead>
<tr>
<th>Study (reference)</th>
<th>No. of organisms at 0 h (CFU/ml)</th>
<th>Increase in significant growth (%) at:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4 h 24 h 48 h 72 h</td>
</tr>
<tr>
<td>Lum and Meers (31)</td>
<td>38</td>
<td>11 137 187 ND</td>
</tr>
<tr>
<td>Hindman et al. (30)</td>
<td>47</td>
<td>9 ND ND ND</td>
</tr>
<tr>
<td>Porter and Brodie (28)</td>
<td>40</td>
<td>ND ND ND 233</td>
</tr>
</tbody>
</table>

*The quality rating of each study was fair. ND, not determined.*

**TABLE 4** Results of immediate versus delayed culture of urine preserved in boric acid or refrigerated

<table>
<thead>
<tr>
<th>Study (reference)</th>
<th>Preservative</th>
<th>Time zero storage conditions</th>
<th>Storage conditions for delayed culture</th>
<th>Positivity threshold (CFU/ml)</th>
<th>% sensitivity (95% CI)</th>
<th>% specificity (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lauer et al. (35)</td>
<td>GBF</td>
<td>Refrigeration</td>
<td>18–24 h in GBF</td>
<td>$&gt;10^6$</td>
<td>93 (86–97)</td>
<td>100 (99–100)</td>
</tr>
<tr>
<td>Gillespie et al. (29)</td>
<td>BA</td>
<td>&lt;8 h in BA</td>
<td>Overnight in BA</td>
<td>$&gt;10^6$</td>
<td>76 (68–82)</td>
<td>96 (94–97)</td>
</tr>
<tr>
<td>Guenther and Washington (33)</td>
<td>GBF</td>
<td>Refrigeration</td>
<td>24 h in GBF</td>
<td>$&gt;10^6$</td>
<td>87 (78–93)</td>
<td>ND</td>
</tr>
<tr>
<td>Lauer et al. (35)</td>
<td>GBF</td>
<td>Refrigeration</td>
<td>18–24 h of refrigeration</td>
<td>$&gt;10^6$</td>
<td>93 (86–97)</td>
<td>100 (100–100)</td>
</tr>
</tbody>
</table>

*The quality rating of each study was fair. GBF, glycerol-boric acid-sodium formate; BA, boric acid; 95% CI, 95% confidence interval; ND, not determined.*
Weinstein (46) compared midstream clean-catch specimens to specimens collected by suprapubic aspiration in a group of patients with spinal cord injury without indwelling catheters. Significant growth in one study (47) was defined as \( \geq 10^5 \) CFU/ml of a single or predominant species for midstream clean-catch specimens or \( \geq 10^5 \) CFU/ml for specimens collected by straight catheterization or suprapubic aspiration. Significant growth in the second study (48) was defined as any growth of \( \geq 10^6 \) CFU/ml for either collection method.

**Body-of-Evidence Qualitative Analysis**

The evidence comparing levels of contamination after midstream urine collection and uncleansed first-void collection is shown in Fig. 4A. Summary data from both studies (46, 47) found a large (77%) reduction in the odds of contamination in favor of midstream clean-catch over first-void specimens. The strength of this evidence was rated as high. Only one study (46) compared midstream collection with cleansing to midstream collection without cleansing (Fig. 4B). Results showed no difference in contamination between the two methods of collection. However, imprecision was largely due to the small event size. The diagnostic accuracy of midstream urine collection from men, with straight catheterization or suprapubic aspiration used as the reference standard, is shown in Table 4. Data for both studies found high diagnostic sensitivity (82 to 100%)

<table>
<thead>
<tr>
<th>Study (reference)</th>
<th>Preservative(s)</th>
<th>Preservative used for immediate culture</th>
<th>No. of h that culture was delayed (preservative[s])</th>
<th>Threshold (no. of CFU/ml)</th>
<th>No. of specimens subjected to immediate culture</th>
<th>% change from no. after delay</th>
<th>No. of specimens subjected to immediate culture</th>
<th>% change from no. after delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern and Luttrell (36)</td>
<td>GBF</td>
<td>GBF</td>
<td>24 (GBF)</td>
<td>( &gt;5 \times 10^4 )</td>
<td>180</td>
<td>-17.8</td>
<td>8</td>
<td>+500.0</td>
</tr>
<tr>
<td>Lum and Meers (31)</td>
<td>BA</td>
<td>GBF</td>
<td>24 (GBF)</td>
<td>( &gt;10^3 )</td>
<td>146</td>
<td>-2.1</td>
<td>29</td>
<td>+10.3</td>
</tr>
<tr>
<td>Wright et al. (32)</td>
<td>BA, GBF, SBF</td>
<td>None (fresh specimens were used)</td>
<td>24 (BA, GBF, SBF)</td>
<td>( &gt;10^3 )</td>
<td>193</td>
<td>-7.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weinstein (37)</td>
<td>GBF, SBF</td>
<td>GBF</td>
<td>24 (GBF)</td>
<td>( \geq 10^3 )</td>
<td>763</td>
<td>+1.2</td>
<td>106</td>
<td>-8.5</td>
</tr>
<tr>
<td>Hubbard et al. (34)</td>
<td>GBF</td>
<td>GBF</td>
<td>24 (GBF)</td>
<td>( &gt;10^3 )</td>
<td>75</td>
<td>+4.0</td>
<td>25</td>
<td>-12.0</td>
</tr>
<tr>
<td>Porter and Brodie (28)</td>
<td>BA</td>
<td>BA</td>
<td>72 (BA)</td>
<td>( &gt;10^3 )</td>
<td>112</td>
<td>0</td>
<td>18</td>
<td>0</td>
</tr>
</tbody>
</table>

\(^a\) GBF, glycerol-boric acid-formate; BA, boric acid; SBF, sorbitol-boric acid-formate; NSG, nonsignificant growth; SG, significant growth. All studies were given a quality rating of fair.

\(^b\) There were 7 fewer patient samples available for analysis with delayed culture (862 patient pairs versus 869); the percent increase was calculated assuming 869 pairs.

in the odds of contamination between midstream urine specimens collected with or without cleansing. The overall strength of this evidence was rated as high. The diagnostic accuracy of midstream urine collection with or without cleansing is shown in Table 9. Using catheterization as the reference standard, midstream collection had a sensitivity of 98 to 100% and a specificity of 95 to 100%. However, the overall strength of this body of evidence was rated as low.

**COLLECTION OF URINE FROM MEN**

Summary information on the three published studies comprising the body of evidence for the clinical questions on contamination and diagnostic accuracy of midstream urine collection from adult males is presented in Tables 10 and 11. One study (46) was given a quality rating of “good,” and two studies (47, 48) were rated as “fair.” Two studies (46, 47) examined contamination in midstream clean-catch specimens compared to that in first-void collection specimens (Table 10). Patients in both studies were either ambulatory or hospitalized men with symptoms of urinary tract infection being seen at a VA Medical Center. In the first study (46), men had a first-void and/or midstream urine sample collected, but only half of the patients were asked to wash their glans penis prior to collection. In the second study (47), urine specimens from men were obtained by midstream clean-catch collection, first-void collection, straight catheterization, and suprapubic bladder aspiration, with 7 men being sampled more than once. Contamination was defined as either the growth of \( >10^5 \) CFU/ml of two or more colony types (46) or any growth of three or more microbial species (47). For the meta-analysis, only those samples obtained via midstream clean-catch collection and first-void collection without cleansing were compared.

Two studies (47, 48) examined the diagnostic accuracy of midstream urine collection from men using either straight catheterization or suprapubic aspiration as the reference standard (Table 11). One study (47) compared midstream clean-catch specimens to those collected by suprapubic aspiration or straight catheterization in a group of hospitalized or ambulatory men, while the second study (48) compared midstream clean-catch specimens to specimens collected by suprapubic aspiration in a group of patients with spinal cord injury without indwelling catheters. Significant growth in one study (47) was defined as \( \geq 10^4 \) CFU/ml of a single or predominant species for midstream clean-catch specimens or \( \geq 10^5 \) CFU/ml for specimens collected by straight catheterization or suprapubic aspiration. Significant growth in the second study (48) was defined as any growth of \( \geq 10^6 \) CFU/ml for either collection method.

**TABLE 6 Effect of delayed plating of urine specimens kept refrigerated**

<table>
<thead>
<tr>
<th>Study (reference)</th>
<th>Threshold (no. of CFU/ml)</th>
<th>NSG present</th>
<th>SG present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of specimens subjected to immediate culture</td>
<td>% change from no. after delay</td>
<td>No. of specimens subjected to immediate culture</td>
</tr>
<tr>
<td>Weinstein (37)</td>
<td>( \geq 10^7 )</td>
<td>758</td>
<td>+0.9</td>
</tr>
<tr>
<td>Hubbard et al. (34)</td>
<td>( &gt;10^3 )</td>
<td>74</td>
<td>0</td>
</tr>
</tbody>
</table>

\(^a\) Both studies were given a quality rating of fair. NSG, nonsignificant growth; SG, significant growth. Both studies immediately cultured fresh specimens and specimens that had been kept under refrigeration for 24 h.

\(^b\) There were 7 fewer patient samples available for analysis with delayed culture (862 patient pairs versus 869); percentages of increase were calculated assuming 869 pairs.
**TABLE 7** Body-of-evidence table for clinical question 3, namely, “what is the difference in percentages of contamination between midstream urine collection with cleansing versus without cleansing in women being tested for a UTI?”

<table>
<thead>
<tr>
<th>Study (reference), quality rating</th>
<th>Population and/or samples</th>
<th>Setting</th>
<th>Time period</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blake and Doherty (38), fair</td>
<td>50 asymptomatic females aged 14–23 yr nonrandomly assigned to the MSCC group (n = 25) or the MS group (n = 25)</td>
<td>Adolescent Clinic, University of Massachusetts Medical School, Worcester, MA</td>
<td>2 mo</td>
<td>Contamination was defined as growth of bacteria found in normal vaginal or skin flora that does not cause UTI. 8 samples showed no growth in the MSCC group, and 5 showed no growth in the MS group. 1 sample in the MS group grew pathogenic bacteria (&lt;2,000 CFU/ml). The remaining 36 samples were contaminated. Of the remaining 36, 33 grew mixed Gram-positive colonies, 2 grew mixed Gram-negative and -negative colonies, and 1 grew staphylococcal species.</td>
</tr>
<tr>
<td>Bradbury (42), fair</td>
<td>158 female patients suspected of having UTIs and 158 controls, all aged 16–75 yr. 316 urine specimens were collected via MSCC or MS. The control group comprised the next nonpregnant female attending with no urinary tract symptoms. Urine was collected into a sterile boric acid container. Specimens were transported to the laboratory after morning surgery. Those collected in the evening were stored in the refrigerator. All specimens were collected at surgery.</td>
<td>General practice, United Kingdom</td>
<td>Not given</td>
<td>Contamination was defined by the presence of epithelial cells. There were 11 contaminated specimens among the 176 in the MSCC group and 17 contaminated specimens among the 138 in the MS group.</td>
</tr>
<tr>
<td>Holliday et al. (39), good</td>
<td>192 asymptomatic antenatal ambulatory women randomly allocated into the MSCC or MS group for urine specimens. No preservatives were used, and samples were processed within 2 h of collection.</td>
<td>Royal Air Force Institute of Pathology and Tropical Medicine, United Kingdom</td>
<td>Not given</td>
<td>Contamination was defined as mixed growth of &lt;10^5 CFU. There were 14 contaminated samples from the 96 women in the MSCC group and 12 contaminated samples from the 96 women in the MS group.</td>
</tr>
<tr>
<td>Schlager et al. (40), good</td>
<td>100 pregnant asymptomatic adolescents aged 10–19 yr in all stages of pregnancy who enrolled during a routine prenatal visit. Each patient provided 2 urine samples collected during consecutive urinations (MSCC or MS). No preservatives were used. Urinalysis and bacterial culture were performed within 5 h of collection.</td>
<td>Teen Health Center, University of Virginia Health Sciences Center, VA</td>
<td>Not given</td>
<td>Contamination was defined as &lt;10^5 CFU/ml of a pathogen or any no. of nonpathogens. There were 62 contaminated samples from the 100 women in the MSCC group and 55 from the 100 women in the MS group (P = 0.38).</td>
</tr>
<tr>
<td>Schneeberger et al. (43), fair</td>
<td>113 pregnant women. 3 urine samples were self-obtained from each woman by UFV, MS, and MSCC. Oral and written instructions were provided. Urine samples were refrigerated and analyzed within 48 h of collection</td>
<td>Obstetric clinic (Vida) in Amsterdam, Netherlands</td>
<td>1 yr</td>
<td>Contamination was defined as growth of at least 2 or more organisms. 336 urine samples were analyzed (113 UFV, 112 MS, and 111 MSCC specimens). There was 1 contaminated specimen out of 112 MS specimens and 3 contaminated specimens out of 113 MSCC specimens. If contamination was defined as growth of ≥10^4 CFU of skin flora/ml by culture, there were 47 contaminated specimens out of 112 MS and 42 contaminated specimens out of 111 MSCC specimens.</td>
</tr>
</tbody>
</table>

*a* MSCC, midstream collection with perineal cleansing; MS, midstream collection; UFV, first-void urine collection (morning).
TABLE 8 Body-of-evidence table for clinical question 4, namely, “what is the accuracy of midstream urine collection, with or without cleansing, compared to catheterization for the diagnosis of UTI in women?”

<table>
<thead>
<tr>
<th>Study (reference), quality rating</th>
<th>Population and samples</th>
<th>Setting</th>
<th>Time period</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walter and Knopp (41), good</td>
<td>105 women suspected of having a UTIs and presenting to the emergency department triage nurse. An MSCC specimen and then a CATH specimen were collected.</td>
<td>Department of Emergency Medicine, Valley Medical Center, Fresno, CA</td>
<td>7 mo</td>
<td>SG was defined as $&gt;10^6$ CFU/ml of a single species by either CATH or MSCC. All other growth was considered NSG. MSCC had a sensitivity of 98% and a specificity of 97%.</td>
</tr>
<tr>
<td>Lemieux and St.-Martin (45), fair</td>
<td>The study was separated into 3 groups. In group 1, 53 healthy student nurses volunteered for MSCC with no CATH. Group 2 consisted of 29 women, asymptomatic for UTI, admitted to a general medical ward. Both MSCC and CATH specimens were collected. Group 3 consisted of 27 patients suspected of having a UTI who were admitted to a semiprivate or general medical ward. Both MSCC and CATH specimens were collected.</td>
<td>Hotel-Dieu Hospital, Montreal, Canada, and Department of Medicine, University of Montreal School of Medicine, Montreal, Canada</td>
<td>Not given</td>
<td>SG was defined as $&gt;10^6$ CFU/ml of a single pathogenic species by either CATH or MSCC. All other growth was considered NSG. Combining groups 2 and 3 yielded a sensitivity of 100% and a specificity of 100%.</td>
</tr>
<tr>
<td>Immergut et al. (44), fair</td>
<td>95 ambulatory females. Urine was obtained via MS or CATH. Specimens were immediately cultured on Uricult medium by dipping the slides into plastic cups.</td>
<td>Private practice, Bethesda, MD</td>
<td>Not given</td>
<td>SG was defined as any growth of $&gt;5 	imes 10^4$ CFU/ml by either CATH or MS. All other growth was considered NSG. MS had a sensitivity of 100% and a specificity of 95%.</td>
</tr>
</tbody>
</table>

* MSCC, midstream collection with perineal cleansing; MS, midstream collection; CATH, catheterization.

and specificity (92 to 100%) for midstream clean-catch collection. However, the overall strength of this body of evidence was rated as low.

COLLECTION OF URINE FROM CHILDREN

Summary information on the 14 published studies comprising the body of evidence for the clinical questions on contamination rates and the diagnostic accuracy of midstream urine collection from children is presented in Tables 13 and 14. Four studies (49–52) were given a quality rating of “good,” and 10 studies (53–62) were rated as “fair.” Six studies (49, 50, 53–56) compared differences in contamination rates in urine collected by midstream collection (with or without cleansing), collected with a sterile urine bag, or collected from diapers (Table 13). Patients studied ranged in age from 1 month to 18 years. Definitions of contamination varied among studies and included mixed growth in any concentration (54), mixed growth in any concentration or any growth of $<10^5$ CFU/ml (49–51), and mixed growth at a concentration of $>10^5$ CFU/ml (56); any specimen interpreted as contaminated by the clinical microbiology laboratory was also included (53).

Eight studies (51, 52, 57–62) examined the accuracy of midstream clean-catch, sterile urine bag, or diaper collection, with suprapubic aspiration or straight catheterization used as the reference standard for diagnosing urinary tract infections in children (Table 14). Patient age ranged from 0 to 10 years. Definitions of significant growth varied across studies, particularly for the reference standards. All studies except one defined significant growth for midstream clean-catch, sterile urine bag, or diaper collection as $\geq 10^5$ CFU/ml. The remaining study (52) defined significant growth by sterile urine bag collection as “pure growth.” Significant growth for suprapubic aspiration or straight catheterization

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**FIG 3** Difference in contamination levels between midstream urine collected with cleansing (MSCC) versus without cleansing (MS) in women being tested for urinary tract infection. M–H, Mantel-Haenszel statistic; 95% CI, 95% confidence interval.
was defined as any growth in one study (51), growth of $\geq 10^2$ CFU in one study (59), growth of $\geq 10^3$ CFU/ml in one study (62), growth of $\geq 10^4$ CFU/ml in three studies (57, 60, 61), and “pure growth” in one study (52). In one study (58), the definition of significant growth was unclear.

**Body-of-Evidence Qualitative Analysis**

The evidence comparing contamination rates for midstream urine collection with cleansing, midstream collection without cleansing, sterile urine bag collection, and diaper collection is shown in Fig. 5. Data obtained from five observational studies (49, 53–56) and one cluster-randomized controlled trial (50) found larger reductions (68 to 73%) in the odds of contamination for specimens obtained by midstream collection with cleansing than for specimens obtained by the other methods of collection. Data from three observational studies (49, 54, 55) found no significant differences in the odds of contamination between specimens collected with sterile urine bags and specimens taken from diapers. This body of evidence was rated as high.

The accuracy of results for midstream clean-catch urine specimens, sterile urine bag specimens, or diaper specimens, with straight catheterization or suprapubic aspiration used as the reference standard for the diagnosis of urinary tract infection in children, is shown in Fig. 6. Data from eight observational studies showed varied results. The inability to meta-analyze the point estimates of sensitivity and specificity due to small sample and study sizes, together with heterogeneity in positivity thresholds, made interpretation difficult. Similarly, HSROC curves could not be generated, and thus it is unclear which method of noninvasive urine collection is most accurate for the diagnosis of urinary tract infection in children.

**ADDITIONAL CONSIDERATIONS**

This section addresses additional considerations for evaluating preanalytical practices associated with urine cultures and the impact of these practices on contamination and diagnostic accuracy.

**Clinical Applicability**

The studies included in this review reported collection, storage, and preservation of urine samples through commonly used methods for both children and adults in both inpatient and outpatient settings; results are therefore likely to apply to other health care environments. Many of the methods for collection, storage, and preservation are widely recommended (18, 63) and are typically used in most hospitals, outpatient clinics, and clinical microbiology laboratories today (21, 22). The focus of this review, however, is largely on clean-catch midstream urine collection because this method remains the most commonly used in most patient populations and settings (18). This is primarily due to its noninvasiveness; i.e., it has no risk of producing iatrogenic infection, despite the paucity of data supporting its use as a standard (63).

Controversy remains among clinical microbiologists and infectious disease physicians about the most accurate means for diag-

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**TABLE 9** Accuracy of midstream clean-catch or midstream urine collection compared to catheterization for the diagnosis of UTI in women

<table>
<thead>
<tr>
<th>Study (reference)</th>
<th>Quality rating</th>
<th>Subpopulation</th>
<th>Index test</th>
<th>Positive threshold for reference standard (CFU/ml)</th>
<th>Positive threshold for index test (CFU/ml)</th>
<th>% sensitivity (95% CI)</th>
<th>% specificity (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walter and Knopp (41)</td>
<td>Good</td>
<td>ND</td>
<td>MSCC</td>
<td>$&gt;10^4$</td>
<td>$&gt;10^4$</td>
<td>98 (88–100)</td>
<td>97 (89–99)</td>
</tr>
<tr>
<td>Lemieux and St.-Martin (45)</td>
<td>Fair</td>
<td>Combined</td>
<td>MSCC</td>
<td>$&gt;10^4$</td>
<td>$&gt;10^4$</td>
<td>100 (87–100)</td>
<td>100 (89–90)</td>
</tr>
<tr>
<td>Immergut et al. (44)</td>
<td>Fair</td>
<td>ND</td>
<td>MS</td>
<td>$&gt;5 \times 10^4$</td>
<td>$&gt;5 \times 10^4$</td>
<td>100 (44–100)</td>
<td>95 (88–98)</td>
</tr>
</tbody>
</table>

MSCC, midstream clean-catch collection; MS, midstream urine collection; ND, not determined. The reference standard for all tests was catheterization.

**TABLE 10** Body-of-evidence table for clinical question 5, namely, “what is the difference in contamination between midstream urine collection, with or without cleansing, from first void collection from men?”

<table>
<thead>
<tr>
<th>Study (reference), quality rating</th>
<th>Population and samples</th>
<th>Time period</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipsky et al. (46), good</td>
<td>254 men attending a urology clinic. 308 specimens were obtained by UFV and MS. Half of the men (those with even Social Security numbers) cleansed their glans penis, creating 4 distinct groups of specimens: UFV, CFV, MS, and MSCC. All specimens were immediately refrigerated and delivered to a laboratory within 4 h of collection.</td>
<td>7 mo</td>
<td>Contamination was defined as $\geq 10^7$ CFU/ml of 2 or more colonial types with no predominant organism. 10 (6.4%) of the 157 MSCC specimens were contaminated. 23 (15.2%) of the 151 UFV specimens were contaminated. 16 (10.6%) of the 151 MS specimens were contaminated.</td>
</tr>
<tr>
<td>Lipsky et al. (47), fair</td>
<td>66 ambulatory or hospitalized men who had acute dysuria or other irritative genitourinary symptoms, were known to have bacteriuria, or were scheduled for urologic procedure. 76 specimens in total from the 66 men (7 patients were restudied [5 twice and 2 four times]) obtained by SPA, UFV, MSCC, and CATH. The specimens were delivered to the laboratory within 30 min of collection and immediately inoculated.</td>
<td>Not given</td>
<td>Contamination was defined as specimens containing more than 2 microbial species. None (0%) of the 75 specimens in the MSCC group were contaminated. 5 (6.9%) specimens of the 72 in the UFV group were contaminated.</td>
</tr>
</tbody>
</table>

MS, unclean midstream urine collection; MSCC, midstream clean-catch collection; UFV, first-void urine collection without cleansing; CFV, first-void collection with cleansing; SPA, suprapubic aspiration; CATH, urethral catheterization. The setting for these studies was the VA Medical Center, Seattle, WA.
nosing urinary tract infections, including the best methods of specimen collection for women, men, children, and infants (19, 63). A recent collaboration between the American Society for Microbiology (ASM) and the Infectious Disease Societies of America (IDSA), designed to assist physicians in the appropriate use of laboratory tests for infectious diseases, addressed methods of specimen collection, as well as guidelines for testing patients for urinary tract infections (64). A recommendation was made for collection of urine in a manner to minimize contamination and included midstream collection with cleansing and immediate refrigeration of samples upon collection, although the lack of supporting data was cited (64).

In applying the findings of this review, a strength assessment of the overall body of evidence should be weighted by the quality of findings from individual reports most closely resembling populations and settings of particular interest. For instance, an overall body-of-evidence quality rating may decrease because of the aggregate number of included studies omitting study parameters of little applicability to a particular clinical setting. Researchers may take guidance, with a higher degree of confidence than the overall quality rating might indicate, from individual included studies of high or moderate strength which address specific clinical populations or settings directly comparable to their research interests. The conduct of evidence-based practice would guide clinicians to assess both the quality and the “goodness of fit” of studies relevant to their own particular questions before applying findings in support of their decisions.

This review has directed attention to the need for reexamination of preanalytic factors affecting urine culture. A great number

### TABLE 11

Table of body-of-evidence table for clinical question 6, namely, “what is the accuracy of midstream urine collection compared to straight catheterization or suprapubic aspiration for the diagnosis of UTI in men?”

<table>
<thead>
<tr>
<th>Study (reference), quality rating</th>
<th>Population and samples</th>
<th>Setting(s)</th>
<th>Time period</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipsky et al. (47), fair</td>
<td>66 ambulatory or hospitalized men who had acute dysuria or other irritative genitourinary symptoms, were known to have bacteriuria, or were scheduled for a urologic procedure. 76 specimens in total were obtained from the 66 men (7 patients were restudied [5 twice and 2 four times]) obtained by SPA, UFV, MSCC, and CATH. Specimens were delivered to the laboratory within 30 min of collection and immediately inoculated.</td>
<td>VA Medical Center, Seattle, WA</td>
<td>Not given</td>
<td>SG was defined as ≥10^8 CFU/ml of a single or predominant species (≥96% of the plate’s growth) for MSCC and ≥10^7 for SPA/CATH. All other growth was considered NSG. MSCC had a sensitivity of 82.4% and a specificity of 100.0%.</td>
</tr>
<tr>
<td>Deresinski and Perkash (48), fair</td>
<td>53 male spinal cord injury patients who were free of indwelling catheters. 71 samples of urine were obtained, 1 by MSCC and 1 by SPA. Note that many of the MSCC specimens were collected on first void. Urine specimens were processed for culture immediately.</td>
<td>Spinal Cord Injury Service, VA, and Stanford University Medical Centers, Palo Alto, CA</td>
<td>Not given</td>
<td>SG was defined as any growth of &gt;10^3 CFU/ml for MSCC and SPA. All other growth was considered NSG. MSCC had a sensitivity of 100% and a specificity of 100%.</td>
</tr>
</tbody>
</table>

### Notes
- MSCC, midstream clean-catch collection; UFV, first-void urine collection without cleansing; SPA, suprapubic aspiration; CATH, urethral catheterization; SG, significant growth; NSG, nonsignificant growth.

### FIG 4

Difference in contamination levels between midstream collection with cleansing (MSCC) and first-void urine collection without cleansing (UFV) (A) or midstream collection without cleansing (MS) (B) for men.
of the studies covered in the review predate the regionalization and other significant restructuring of the delivery of microbiological services in the United States, which portend increased variation in collection, storage, and preservation methods. More studies are needed to support recommendations for specific populations, e.g., nursing facility residents needing skilled care. Important also is the growing need for documentation of health outcomes and cost-effectiveness of current practices through the implementation of well-designed, system-wide quality improvement studies. Of equal importance is the need to expand (and

### Table 12: Diagnostic accuracy of MSCC compared to SPA or CATH for the diagnosis of UTI in men

<table>
<thead>
<tr>
<th>Study (reference)</th>
<th>Reference standard(s)</th>
<th>Reference threshold for reference test (no. of CFU/ml)</th>
<th>Reference threshold for index test (no. of CFU/ml)</th>
<th>% sensitivity (95% CI)</th>
<th>% specificity (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipsky et al. (46)</td>
<td>SPA/CATH</td>
<td>≥10⁴</td>
<td>≥10⁴</td>
<td>82 (67–92)</td>
<td>100 (92–100)</td>
</tr>
<tr>
<td>Deresinski and Perkash (48)</td>
<td>SPA</td>
<td>&gt;10⁴</td>
<td>&gt;10⁴</td>
<td>100 (92–100)</td>
<td>100 (87–100)</td>
</tr>
</tbody>
</table>

a MSCC, midstream clean-catch collection; SPA, suprapubic aspiration; CATH, straight catheterization. The quality rating of both studies was fair, and the index test for both was MSSC.

### Table 13: Body-of-evidence table for clinical question 7, namely, “what is the difference in contamination between MSCC, MS, SUB, and diaper collection from children?”

<table>
<thead>
<tr>
<th>Study (reference), quality rating</th>
<th>Population and samples</th>
<th>Setting</th>
<th>Time period</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karacan et al. (53), fair</td>
<td>1,067 children aged 0–16 yr suspected of having UTIs. Urine was collected by either SUB (n = 517), MSCC (n = 532), CATH (n = 7), or SPA (n = 11). Some SUB and MSCC samples were collected by parents. Within 30 min of collection, all specimens were sent to the laboratory for culture.</td>
<td>Dr. Sami Ulus Children’s Hospital, Ankara, Turkey</td>
<td>2 mo</td>
<td>Contamination was defined as those specimens interpreted as “contaminated” by the laboratory. 76 (14.3%) of 532 MSCC samples were contaminated, compared with 227 (43.9%) of 517 SUB samples.</td>
</tr>
<tr>
<td>Alam et al. (49), good</td>
<td>191 children ≤3 yr without known UTIs. Urine specimens were obtained by 3 different methods: MSCC, DIAPER, and SUB. 534 urine samples were obtained from the 191 children. Urine was cultured within 2 h of arriving at the laboratory.</td>
<td>Institute of Maternal and Child Health of Pernambuco, Recife, Brazil</td>
<td>2 mo</td>
<td>Contamination was defined as mixed growth or any growth of &lt;10⁵ CFU/ml. All specimens with SG of a single species of &gt;10⁵ CFU/ml were excluded. 23 (14.7%) of 156 MSCC specimens were contaminated. 45 (26.6%) of 169 SUB specimens were contaminated. 49 (29.0%) of 169 DIAPER specimens were contaminated.</td>
</tr>
<tr>
<td>Macfarlane et al. (54), fair</td>
<td>88 children of &lt;2 yr with various febrile illnesses had 56 reliable urine samples collected by DIAPER. 34 children of the same age and from the same ward had SUB samples collected. 240 MSCC samples were also included in the study (no. of children not reported).</td>
<td>Departments of Child Health and Microbiology, Rotherham General Hospital, Rotherham, United Kingdom</td>
<td>3 mo</td>
<td>Contamination was defined as mixed growth at any concn. 34 (60.7%) of 56 DIAPER specimens were contaminated. 23 (67.6%) of 34 SUB specimens were contaminated. 64 (26.7%) of 240 MSCC specimens were contaminated.</td>
</tr>
<tr>
<td>Ahmad et al. (55), fair</td>
<td>45 infants aged 1–23 mo. Urine specimens were collected by DIAPER or SUB.</td>
<td>Departments of Child Health and Microbiology, Royal Victoria Infirmary, Newcastle upon Tyne, United Kingdom</td>
<td>Not given</td>
<td>Contamination was defined as mixed growth or any growth of &lt;10⁵ CFU/ml. 17 (37.8%) of 45 SUB specimens were contaminated. 10 (22.2%) of 45 DIAPER specimens were contaminated.</td>
</tr>
<tr>
<td>Vaillancourt et al. (50), good</td>
<td>350 toilet-trained children aged 2–18 yr cluster-randomized by week to urine collection groups. 350 urine specimens were obtained by either MSCC or MS with cleansing of the perineum with soap before midstream collection.</td>
<td>Montreal Children’s Hospital, Montreal, Canada</td>
<td>11 mo</td>
<td>Contamination was defined as mixed growth of 2 or more organisms or any growth of &lt;10⁵ CFU/ml. 14 (7.8%) of 179 MSCC specimens were contaminated. 41 (23.9%) of 171 MS specimens were contaminated.</td>
</tr>
<tr>
<td>Tosif et al. (56), fair</td>
<td>599 children of &lt;2 yr of age (retrospective observational study of urine culture results). Urine specimens were obtained by MSSC, SPA, CATH, or SUB. Contamination rates were stratified according to the method of collection.</td>
<td>Royal Children’s Hospital, Melbourne, Australia</td>
<td>1 mo</td>
<td>Contamination was defined as growth of 2 or more organisms with colony counts of ≥10⁵ CFU/ml. 52 of 202 MSCC specimens were contaminated, and 6 of 13 SUB specimens were contaminated.</td>
</tr>
</tbody>
</table>

a SUB, sterile urine bag collection; MSCC, midstream clean-catch collection; CATH, catheterization; SPA, suprapubic aspiration; DIAPER, diaper collection; SG, significant growth.
### TABLE 14 Body-of-evidence table for clinical question 8, namely, "What is the accuracy of midstream clean-catch, sterile urine bag or diaper collection compared with suprapubic aspiration or catheterization for the diagnosis of UTI in children?"a

<table>
<thead>
<tr>
<th>Study (reference), quality rating</th>
<th>Population and samples</th>
<th>Setting(s)</th>
<th>Time period</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morton and Lawande (57), fair</td>
<td>Children aged &lt;10 yr of age suspected of having UTI. 287 urine specimens were obtained by SPA, and 175 were obtained by MSCC. For only 51 children, MSCC results were compared with SPA results. All samples were refrigerated after collection for a maximum of 12 h until transfer to a laboratory and culture.</td>
<td>Pediatric Department of Ahmadu Bello University Teaching Hospital, Zaria, northern Nigeria</td>
<td>Not given</td>
<td>SG was defined as any growth in SPA specimens and any growth of $&gt;10^3$ CFU/ml in MSCC specimens. All other growth was considered NSG. MSCC had a sensitivity of 100% and a specificity of 100% if one assumes that the 5 specimens of SG collected by MSCC were the same 5 specimens of SG collected by SPA.</td>
</tr>
<tr>
<td>Pylkkanen et al. (58), fair</td>
<td>477 patients (164 infants and 313 children) suspected of having UTIs. Urine specimens were obtained by SPA and SUB from infants ($n = 164$) or by MSCC from children ($n = 313$). Culture was performed immediately after collection.</td>
<td>Outpatient clinic at the Children’s Hospital, University of Helsinki, Finland</td>
<td>Not given</td>
<td>SG was defined as consistent growth on both blood agar and Uricult dipslides for SPA specimens and any growth of $\geq 10^5$ CFU/ml for MSCC specimens. Combining symptomatic and asymptomatic patients, MSCC had a sensitivity of 83.3% and a specificity of 67.7%.</td>
</tr>
<tr>
<td>Aronson et al. (59), fair</td>
<td>120 patients. Cleanly voided urine samples were collected simultaneously with or immediately after SPA. Samples were collected by SUB from infants of $&lt;18$ mo ($n = 86$) and by MSCC from children 3–12 yr of age ($n = 34$). Immediately after collection, samples were chilled and transported to a laboratory for culture.</td>
<td>Department of Pediatrics, University Hospital, Lund, Sweden</td>
<td>Not given</td>
<td>SG was defined as any growth of $\geq 10^7$ CFU/ml for SPA specimens and any growth of $&gt;10^3$ for MSCC specimens. All other growth was considered NSG. MSCC had a sensitivity of 71.4% and a specificity of 80.0%. SUB had a sensitivity of 83.3% and a specificity of 56.5%.</td>
</tr>
<tr>
<td>Hardy et al. (60), fair</td>
<td>30 patients aged 0 to 3 yr of age. Urine was obtained by SUB, MSCC, and SPA. The 3 specimens were collected within 1 to 6 h of each other and not always in the same order. Specimens were collected in sterile plastic bottles and transported immediately for culture or refrigerated until transport later that day.</td>
<td>Department of Pediatrics and Department of Medical Microbiology, The Royal Free Hospital, London</td>
<td>Not given</td>
<td>SG was defined as $\geq 10^5$ CFU/ml of a single species for MSCC, SUB, and SPA specimens. MSCC had a sensitivity of 25.0% and a specificity of 96.2%. SUB had a sensitivity of 50.0% and a specificity of 92.3%.</td>
</tr>
<tr>
<td>Ramage et al. (51), good</td>
<td>49 infants of $&lt;24$ mo of age suspected of having UTIs. 58 paired urine cultures were obtained by MSCC and SPA.</td>
<td>Royal Hospital for Sick Children, Glasgow, Scotland</td>
<td>Not given</td>
<td>SG was defined as any growth in SPA specimens and $&gt;10^3$ CFU/ml of a single species in MSCC specimens. MSCC had a sensitivity of 88.9% and a specificity of 95.0%.</td>
</tr>
<tr>
<td>Cohen et al. (61), fair</td>
<td>38 infants of $&lt;2$ yr of age who presented with fever with no obvious cause. Urine was collected either by SPA/CATH or by DIAPER. All urine was sent within 1 h for culture.</td>
<td>Department of Pediatrics, Sackler School of Medicine, Tel Aviv University, Tel Aviv, Israel</td>
<td>Not given</td>
<td>SG was defined as all growth of $&gt;10^3$ CFU/ml of a single species in DIAPER or SPA/CATH specimens. All other growth was considered NSG. DIAPER had a sensitivity of 100% and a specificity of 94%.</td>
</tr>
<tr>
<td>Grisaru-Soen et al. (52), good</td>
<td>50 infants 0–18 mo of age suspected of having UTIs or neonatal fever indicating urine culture. Urine was collected by SPA and by SUB.</td>
<td>The Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel</td>
<td>Not given</td>
<td>SG was defined as &quot;pure growth” in SPA or SUB specimens. All other growth was considered NSG. SUB had a sensitivity of 100% and a specificity of 83.7%.</td>
</tr>
<tr>
<td>Etoubleau et al. (62), fair</td>
<td>192 non-toilet-trained children of $&lt;3$ yr of age from 2 emergency departments. Urine was obtained by SUB. All children had a positive microscopic examination that prompted collection by CATH.</td>
<td>Department of Pediatrics, Limoges University Hospital, Limoges, France. and Hospital Intercommunal, Poissy, France</td>
<td>Not given</td>
<td>SG was defined as $\geq 10^5$ CFU/ml of a single species in CATH specimens and $\geq 10^4$ CFU/ml of a single species in SUB specimens. All other growth was considered NSG. SUB had a sensitivity of 83.3% and a specificity of 91.1%.</td>
</tr>
</tbody>
</table>

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a SUB, sterile urine bag collection; MSCC, midstream clean-catch collection; CATH, catheterization; SPA, suprapubic aspiration; DIAPER, collection from disposable diapers; SG, significant growth; NSG, nonsignificant growth.
communicate) the literature on diagnostic testing algorithms to include nonanalytic variables, such as those measured in the included studies reported here. This systematic review provides a current and substantial literature base from which to begin investigations not only to address these gaps in current knowledge related to the effects of preanalytic factors on urine culture but also to validate these best-practice recommendations in additional settings and populations.

**Associated Harms**

Methods of collecting, storing, and preserving urine specimens for the diagnosis of urinary tract infections have a critical influence on culture results. Poorly collected or preserved specimens can become easily contaminated with perineal, vaginal, and periurethral flora, which can inhibit or obscure the presence of true urinary tract pathogens. Conversely, the use of high concentrations of boric acid as a preservative has been known to inhibit urinary pathogens such as *Escherichia coli* and *Klebsiella pneumoniae* (65).

Midstream urine collection may be the preferred choice for collection for most patients; however, there are patient populations and clinical scenarios where a more invasive method of collection is preferred (63). All of these issues can produce incorrect culture results, misdiagnosis, especially in asymptomatic patients, poor patient management, including the use of inappropriate or ineffective antibiotics, and potentially more complicated urinary tract infection in the long term (2, 3).

**Additional Benefits**

Urine specimens that are appropriately collected, transported, stored, and preserved benefit patients by producing more-accurate culture results. In addition, such practices can provide benefit to the laboratory by allowing technologists to focus on the work-up of clinically significant pathogens rather than the growth of contaminants. Urine cultures are often a major component of the typical clinical microbiology workload (18); therefore, minimizing the processing of poor-quality urine specimens can allow...
the laboratory to focus its resources in a more cost-effective manner (22).

**Economic Evaluation**

Proper attention to the preanalytic phase of urine cultures should decrease the number of contaminated urine specimens processed by the laboratory. It may also decrease the time it takes for microorganism identification and susceptibility testing of pathogens in infected patients by reducing the number of recollected specimens. Both of these scenarios would likely reduce health care costs for both patients and institutions by reducing the time to appropriate targeted therapy and by making more-effective use of laboratory and hospital resources. However, no economic evaluation analyses were found for the studies covered in this review.

**Feasibility of Implementation**

The methods of specimen collection and handling covered in this review are feasible in all settings and patient populations and are, in fact, commonly used in most medical environments today. There are data showing the benefit of either refrigerating or chemically preserving urine samples that are not immediately processed (28–37). Furthermore, midstream urine collection, with or without cleansing, is common practice for most clinical settings and patient populations (38–62). For facilities that have historically paid little attention to the preanalytic aspects of urine culture, there may be some resistance on the part of patients and staff that is typically associated with quality improvement initiatives. Appropriate education regarding the proper collection of urine specimens may be needed for both patients and health care workers. The additional costs associated with chemical preservatives, such as boric acid, would also need to be budgeted and justified.

**Future Research Needs**

The findings of this systematic review highlight the lack of recent high-quality studies that evaluate components of the preanalytical phase of urine culture. For example, the relative paucity of rigorous studies evaluating methods of storage and chemical preservation of urine specimens is troublesome considering the widespread use of these practices in many laboratories and a general consensus among microbiologists as to their benefit. A large number of the studies suffered from small sample sizes, limiting the precision of the results and reducing the likelihood that findings are applicable across a larger population. Studies also used various or unclear definitions of contamination or positivity thresholds, making meta-analysis or qualitative summary analysis problematic. Studies further suffered from missing data. For example, most studies were cross-sectional or otherwise observational (without randomization) in design, but many, particularly those retrospective in nature, did not obtain or report the results of samples from all patients obtained by all collection methods under study. These inconsistencies lead to significantly uneven comparison groups in some cases.

Future studies should strive for statistically sufficient sample sizes, use common and clearly defined definitions of contamination and positivity thresholds, and report accuracy results across several common positivity thresholds to aid subsequent meta-analysis. An example is the number of positive/negative samples calculated if reviewers use a threshold of $>10^4$ versus $>10^5$ CFU per ml of urine. Studies should also be more rigorous in design, include more randomized controlled trials, and ensure paired sampling when possible in prospective or cross-sectional studies. Moreover, for all methods under evaluation, patients should have urine collected within a reasonable time frame, and the time delay between collection and culture should be clearly reported.

Finally, future studies should strive to obtain data on down-
TABLE 15 Summary of findings of our evidence-based review of urine culture preanalytics

<table>
<thead>
<tr>
<th>Quality issue</th>
<th>Body of evidence quality</th>
<th>Body of evidence strength</th>
<th>Recommended</th>
<th>Not recommended</th>
<th>No recommendation for or against due to insufficient evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delayed processing of urine stored at room temp vs refrigeration vs boric acid</td>
<td>Fair</td>
<td>Low</td>
<td></td>
<td></td>
<td>×</td>
</tr>
<tr>
<td>Midstream urine collection from women with cleansing</td>
<td>Good/fair</td>
<td>High</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midstream urine collection from women without cleansing</td>
<td>Fair</td>
<td>Low</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midstream urine collection from women vs collection by straight catheterization</td>
<td>Fair/good</td>
<td>Low</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midstream urine collection from men with cleansing</td>
<td>Good/fair</td>
<td>High</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midstream urine collection from men without cleansing</td>
<td>Fair</td>
<td>Low</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First-void urine collection from men</td>
<td>Good/fair</td>
<td>High</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midstream urine collection from men vs collection by straight catheterization or suprapubic aspiration</td>
<td>Fair</td>
<td>Low</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midstream urine collection from children with cleansing</td>
<td>Fair/good</td>
<td>High</td>
<td></td>
<td></td>
<td>×</td>
</tr>
<tr>
<td>Midstream urine collection from children without cleansing</td>
<td>Fair/good</td>
<td>High</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urine collection from children with sterile urine bags and/or from diapers</td>
<td>Fair/good</td>
<td>High</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midstream urine collection from children vs collection by straight catheterization or suprapubic aspiration</td>
<td>Fair/good</td>
<td>Low</td>
<td>×</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

stream patient-centered outcomes as influenced by different methods of collection, preservation, or storage of urine that are under evaluation. This broader measurement pool includes system-oriented outcomes, such as time to targeted therapy, cost of antibiotic use, number of UTI discharge diagnoses, or number of *Clostridium difficile* cases avoided, such that the direct or indirect impact of implementing a particular preanalytic practice can be measured at the patient and organizational level. Information provided in Appendix 2 can be used as a guide to organize and plan studies as well as collect data for any quality improvement project that examines preanalytical practices associated with urine cultures.

**Limitations**

The LMBP systematic review method is compatible with other standards of practice for systematic reviews (24) but includes some unique elements, such as the rating of study quality. Rating study quality is based on attributes such as facility description, study setting and design, practice description, outcome measures, and results. How studies are ultimately considered for inclusion in the review depends on consensus assessments that may be influenced by such things as a rater’s professional background and experience. Indeed, several on-topic studies were excluded because of limitations identified during quality evaluation, mostly related to poor reporting of important study, practice, or outcome details. This is likely somewhat explained by the publication dates of many of the studies, with several of both the excluded and included studies having been published in the late 1960s. As is the case with most systematic reviews, attempts were made to limit publication bias by soliciting unpublished data; however, no unpublished data were submitted. Moreover, restricting the review to English-language studies may also introduce bias.

Outside the limitations of the review process, there were a number of limitations in this review that affected the ability to draw firm conclusions and make recommendations. Most of these limitations were addressed above in the context of future research, but additional limitations will be discussed here. The study settings varied across included studies. Both inpatient and outpatient settings were included, and the specific setting examined in each study—emergency department, adolescent clinic, obstetric clinic, etc.—may not be generalizable to other settings. Some settings may be better equipped to perform certain collection methods or to educate patients or parents on how to perform certain collection methods. Similarly, the patient populations under study varied. Some studies included healthy asymptomatic patients, while others included patients with more-severe conditions, such as spinal cord injury patients. This too might affect the generalizability of results. Within the body of evidence for children, studies often included patients ranging in age from 0 to 16 years. Unfortunately, there were not enough data available to properly stratify children, such as infants, into smaller age groups, and because of this, results may not be generalizable to patients of a specific age. Finally, as discussed above, an important limitation was the variability in positivity thresholds and definitions of contamination used across studies. Although several guidelines have been developed to address definitions of significant bacteriuria for culture (18, 63, 66–68), these guidelines are not always consistent, and this lack of consistency is reflected in the studies and results reported in this review.

**CONCLUSIONS AND RECOMMENDATIONS**

A summary of the findings of this evidence-based review of urine culture preanalytics can be found in Table 15. Conclusions are categorized as “recommended,” “not recommended,” or “no recommendation for or against” and refer to studies of urine collected by noninvasive methods:

1. No recommendation for or against is made for delayed processing of urine that is stored at room temperature, refriger-
midstream collection with cleansing is recommended and collection with sterile urine bags, from diapers, or midstream without cleansing is not recommended. Data from six studies, two with a quality rating of “good” and four rated as “fair,” found large reductions in contamination in midstream clean-catch urine specimens compared to contamination after other noninvasive methods of collection. This body of evidence was rated as high. Whether midstream collection with cleansing can be routinely used in place of catheterization or suprapubic aspiration is unclear. Data from eight studies, two with a quality rating of “good” and six rated as “fair,” suggest that midstream collection with cleansing is accurate for the diagnosis of urinary tract infections in infants and children and that midstream collection with cleansing has higher average accuracy than sterile urine bag collection (data for diaper collection was lacking). However, the overall strength of evidence was low, as multivariate modeling could not be performed; thus, no recommendation for or against can be made due to insufficient evidence.

APPENDIX 1
The members of the Laboratory Medicine Best Practices Workgroup from 2012 to 2014 were as follows: Robert H. Christenson, University of Maryland Medical Center, Baltimore, MD; John Fontanesi, UC—San Diego Medical School, La Jolla, CA; Julie Gayken, Regions Hospital, St. Paul, MN; James Nichols, Vanderbilt University Medical Center, Nashville, TN; Mary Nix, Agency for Healthcare Research and Quality, Rockville, MD; Milenko Tanasijevic, Brigham and Women’s Hospital, Boston, MA; Sharon Geaghan, Stanford, University School of Medicine, Stanford, CA; Christine Litwin, Georgia Health Sciences University, Augusta, GA; Thomas Lorey, Permanente Medical Group Regional Laboratory, Richmond, CA; Bernadette Mazurek Melnyk, The Ohio State University, Columbus, OH; Anton Piskac, Methodist Health System, Omaha, NE; Jennifer Rhamy, St. Mary’s Hospital, Oakbrook Terrace, IL; Christopher Lee Roy, Brigham and Women’s Hospital, Boston, MA; and Melissa Singer (ex officio), Centers for Medicare and Medicaid Services, Baltimore, MD.

APPENDIX 2
LMBP Evaluation of Preanalytic Practices for the Contamination and Diagnostic Accuracy of Urine Cultures

Suggested guidance for future studies. This review identified and rated practices associated with the collection, preservation, and storage of urine specimens for culture and assessed the impact of these preanalytic practices on the diagnostic accuracy of urine culture microbiology. In theory, the design, description, methods, data collection, and analysis for any study should be written and documented so that other investigators can reproduce exactly the same study in their laboratory, with their results validating or verifying those of the original study. The following organizational plan with instructions can be used as a guide for quality improvement project design, implementation, and evaluation of preanalytic practices associated with urine cultures. Figure A1 shows a form for use in collecting data for any QI project that examines preanalytical practices associated with urine cultures.
Background Information

1. Problem/quality issue description.
   A. Practices
   i. Collection
      - Midstream clean catch vs. midstream w/o cleansing
      - Midstream clean catch vs. straight catheter/suprapubic aspiration
      - Midstream w/o cleansing vs. straight catheter/suprapubic aspiration
      - Midstream w/o cleansing vs. first void
      - Midstream w/o cleansing vs. diaper collection/sterile urine bag
   ii. Preservation/storage/transport
      - Temperature
      - Refrigeration
      - Formaldehyde
      - Glycolated boric acid
      - Sorbitol boric acid
      - Room temperature
      - Other
   iii. Transport Time
   iv. In lab processing time
   B. Population and age range
      - Male
      - Female
      - Children
      - Infants/Neonates
      - Other
   C. Collection personnel
      - Nurse
      - Nurse aide
      - Physician
      - Specialized urine collection team
      - Lab technologist/technician
      - Other

2. Submitter(s) and org. affiliations
   Name(s) Organization
   Phone/email

3. Funding sources
   - In-house
   - Manufacturer
   - Grant
   - None
   - Other

4. QI project study design/type
   - Pre-post implementation
   - Split implementation (multiple sites)
   - Case-control
   - Cross-sectional
   - Cohort
   - Randomized assignment
   - Other

5. Facility description
   - Hospital
   - Home
   - University based
   - Children’s hospital
   - VA hospital
   - For-profit healthcare group
   - Other
   - Outpatient clinic
   - Pediatric clinic
   - Other

6. QI project study setting
   - Inpatient
   - Outpatient
   - Emergency Department
   - Pediatrics Unit
   - NICU
   - Other

7. Overall project/study time frame (include pilot projects)
   Start ___/End ___.
   Describe:

8. Study sample/population (size and description) describe if different between compared practices.

9. Describe usual practice

10. Describe alternate/intervention practice

11. Intervention duration dates (pilot, pre/post, etc.)
    Phase Start ___/End ___.
    Phase Start ___/End ___.
    Phase Start ___/End ___.
    Describe:

12. Resource requirements/costs:
   A. Staff / Training
   B. Equipment/Supplies
   C. Other

13. Outcome measure(s)
   - Changes in urine culture colony counts
   - Contamination - How measured?
   - Diagnostic accuracy
   - Number of organism IDs and ASTs
   - Other additional laboratory tests
   - Antibiotic use
   - Repeat urine collection
   - Number of UTI discharge diagnoses
   - Length of stay
   - Other

14. Recording method (how data was collected / note any differences between standard and test practices)
   - Logs of occurrence
   - Incident/adverse events reports
   - Audit – direct observation
   - Electronic information system monitoring
   - Other
   Describe each checked method and which practice it refers to

15. Potential sources of bias
   - Selection bias
   - Performance bias
   - Detection bias
   - Confounding
   - Reporting bias
   - Other

16. Results/findings as (related to study design/outcome measure)

17. Data analysis – statistics
   - t-test
   - Relative risk
   - Accuracy or agreement related statistics (sensitivity, specificity, PPV, NPV, AOR kappa etc.)
   - Other

18. Data analysis significance
   - t-test
   - Fisher Exact
   - Chi-square
   - Other

19. Barriers to implementation (an event outside of study that impacts study results)

20. Study dates completed/submitted
    Completed:
    Reported on Web? (When? Date?)

FIG A1 Form for use in collecting data for any QI project that examines preanalytical practices associated with urine cultures.

Background Information

1. Problem/quality issue description.
   A. Practices and equipment. Describe what preanalytic practices associated with the collection and preservation of urine for culture were studied and exactly how specimens were collected. Include examples of educational material handed to patients or displayed on walls in areas where patients were seen.
   i. Collection. Indicate whether specimens were obtained by midstream clean-catch collection versus midstream collection without cleansing, midstream clean-catch collection versus straight catheter collection and/or suprapubic aspiration, midstream collection without cleansing versus straight catheter collection and/or suprapubic aspiration, midstream collection with or without cleansing versus first-void urine collection, midstream collection with or without cleansing versus diaper collection and/or sterile urine bag collection, or other means.
   ii. Preservation/storage/transport. Include the time from collection of the specimen to the addition of preservative and how long it took the specimen to reach the lab after collection, as well as how long it took from receipt in the lab to setup of culture. Indicate whether boric acid, glycerol boric acid, or sorbitol boric acid was used as a preservative, whether the specimen was stored in a refrigerator or at room temperature, and any other relevant preservation or storage information.
   B. Population under study and age ranges. Include physical differences which may affect the collection of the specimen, such as physical disability, the presence of a foreskin in males, the presence of diapers, etc. With infants and neonates, consider tighter age ranges, such as 0 to 2, 2 to 4, etc.
   C. Collection personnel. Indicate whether the specimen was collected by a nurse, nurse’s aide, physician, specialized urine collection team, lab technologist or technician, or other staff member.

2. Submitter(s) and organization affiliation. For additional
questions concerning the quality improvement (QI) study, contact information is required.

3. Funding source(s). Refer to the chart in Fig. A1. Check all boxes that apply.

QI Project/Study

4. QI project study design/type. With similar patient populations, describe the methods/approaches used for your project with regard to age, sex, ethnicity, and/or diagnosis to limit bias.
   A. Pre- and postimplementation. Observations are made before and after the implementation of an intervention.
   B. Split implementation design. Indicate whether multiple sites were used to conduct the QI study.
   C. Case-control study. Indicate whether the study compared subjects with a specific outcome of interest (cases) with subjects from the same source population but without that outcome (controls) to examine the association between the outcome and prior exposure (for which there was an intervention).
   D. Cross-sectional associations. Collect information on interventions (past or present) and current health outcomes, i.e., those that are restricted to health states, for a group of people at a particular point in time, to examine associations between the outcomes and exposure to interventions.
   E. Cohort. A defined group of people (the cohort) is followed over time to examine associations between different interventions received and subsequent outcomes.
   F. Randomized assignment. Patients are randomly selected to receive the intervention practice or the comparator practice.
   G. Other study design used in this QI project. Describe the study design selected.

5. Facility description. Provide a complete description of the facility type and the number of beds (or patients if the facility is an outpatient facility).

6. Study setting. Select the unit(s) within the facility where the practice was implemented, e.g., inpatient, outpatient, emergency department, pediatric unit, neonatal intensive-care unit, or other.

7. Overall project/study time frame. Record the start and end dates for the new and usual practices; if pilot testing was conducted, include start/end dates for pilot testing of the new practice. Note that this is not the same as the QI study period but rather the dates during which these practices were being used in the unit(s) in which the study was done. Put “NA” if some dates are not available.

8. Sampling strategy. The sample size is the number of patients/observations used for the usual (current) practice and the alternate practice. Use the largest available sample size at each time of measurement. For results to be reliable, the implemented practice should be the only thing affecting the results. It is the largest sample size available that represents only the results of the usual practice and the largest sample size that represents only the results of the alternate practice. Describe your sample set (tests, patient specimens, patients, or type of patient specimens) and the sample size (example: prior to [usual] practice [15,000 patient specimens tested] and after [alternate] practice [13,200 patient specimens tested]).

Optimally, a power analysis should be performed prior to confirmation of sample size. Statistical power is the probability of concluding that there is a difference when there is, in fact, a difference between your standard method and your new method (i.e., the probability that your study will detect a difference, given that one truly exists). An example of a nomogram for sample size calculation can be found in reference 69.

9. Describe the original (usual) practice. Describe the original (usual) practice(s) that will be compared to the new practice/policy/technology implemented.

10. Describe the alternate/intervention (new) practice. Describe the new practice/policy/technology, including the characteristics and components for ongoing day-to-day operations.

11. Intervention duration dates (pilot, pre/postintervention, etc.). Record the start and end dates for the pilot testing, usual practice, and new practice. This is the date on which the particular QI project was implemented and the date on which it ended. Note that a pilot test may not have been used in this study. There should be no gaps in the QI project data collection once it begins.

12. Resource requirements/costs. Describe the requirements and costs for starting and sustaining the new practice during the study. If this information is not available, list “not known.” Do not list the cost of the practice that is currently being used to do patient testing.

Outcome Measures

13. Outcome measure(s). Describe how the impact of the practice was measured. Provide the specific outcome(s) and corresponding specifications/definitions used to assess or track the impact of the practices implemented. An example is a description of how urine culture contamination rates were affected or how they had an impact on the diagnostic accuracy of urine culture.
14. Recording method. Describe each method used to collect data and to which practice (usual or new) it refers.

15. Potential sources of bias. Bias is the tendency to produce results that depart systematically from the “true” results. Bias is any nonrandom factor in the conduct of a study that can influence the results of a study.

A. Selection bias. Selection bias occurs when studies are conditioned on (that is, they differentially select for) common effects of the exposure and the outcome. Selection bias occurs after exposure and arises when the associations between exposure and outcome are different for those who participate and those who do not participate in a study (i.e., all those who are theoretically eligible). This bias includes inappropriate selection of controls in a case-control study, different losses to follow-up for groups being compared (attrition bias), incidence/prevalence bias, nonresponse bias, and inclusion or exclusion of specific groups for study.

B. Performance bias. Performance bias includes systematic differences in the types of care provided to participants and protocol deviations. Examples include contamination of the control group with the exposure or intervention, unbalanced provision of additional interventions or cointerventions, a difference in cointerventions, and providers and participants not being adequately blind to the study results.

C. Detection bias. Detection bias includes systematic differences in outcome assessments among groups being compared. Reasons for this bias include misclassification of the exposure, intervention, covariates, or outcomes because of varying definitions, timings, diagnostic thresholds, and memories of an event; assessors not being adequately blind to the study results; and faulty measurement techniques. Erroneous statistical analysis might also affect the validity of effect estimates.

D. Confounding bias. Confounding bias is the presence of systematic differences between baseline characteristics of the groups that arise when patient prognostic characteristics, such as disease severity or comorbidity, influence both treatment source and outcomes. Confounders are the common cause for intervention and exposure; they occur before exposure. Confounding by indication can occur from self-selection of treatments or physician-directed selection of treatments.

E. Reporting bias. Reporting bias is the presence of systematic differences between reported and unreported findings (e.g., differential reporting of outcomes or harms, incomplete reporting of study findings, and potential for bias in reporting through source of funding).

Results/Findings

16. Results/findings as related to study design/outcome measure. For each outcome provided, summarize the results/findings of the study/project related to the practice. Provide the total number of observations (samples) on which the results are based and statistical tests results, if a statistical analysis was performed. Include findings related to cost savings or shortened length of stay, if applicable.

17. Data analysis with regard to statistics. Describe the statistic used to measure the strength of association or the statistical measures of the performance of classification tests (e.g., sensitivity, specificity). Examples are as follows.

A. With first-void urine collection, 10 urine samples are contaminated per 100 urine cultures performed (10% contamination rate).

B. With midstream clean-catch urine collection, 3 urine samples are contaminated per 100 urine cultures performed (3% contamination rate).

C. The odds ratio is 0.28 (3/10/97/90).

18. Data analysis with regard to significance. Describe the tests of significance. Include calculations of the statistical significance of a difference between the usual practice and the alternate practice on the measured outcomes listed in item 14.

19. Barriers to implementation. Describe any outside activities occurring at the same time as the project, such as staff changes or new policy, that may have influenced the results of the project. Describe any barriers that directly impacted the project.

20. Study dates completed or report submitted. Dates should include the date that the study was completed, the date it was reported (and where it was reported), and the date it was submitted to the LMBP initiative.

APPENDIX 3

Refer to Tables A1 to A4 for evidence summaries of results for storage (refrigeration versus room temperature) and boric acid preservation of urine, contamination and diagnostic accuracy of urine collected from women, contamination and diagnostic accuracy of urine collected from men, and contamination and diagnostic accuracy of urine collected from children.
### TABLE A1 Evidence summary table for storage (refrigeration versus room temperature) and boric acid preservation of urine

<table>
<thead>
<tr>
<th>Study</th>
<th>Practice</th>
<th>Outcome measures</th>
<th>Results/findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design: nonrandomized comparison study Facility/setting: 300-bed teaching hospital Time period: not given Population/sample: 100 random specimens of urine submitted for culture and received by the laboratory within 2 h of the stated time of collection Comparator: not reported Study bias: sample size</td>
<td>Description: evaluation of the impact of time delay between collection and culture of urine samples Duration: not reported Training: not reported Staff/other resources: not reported Cost: not reported</td>
<td>Description: to determine the impact of delay in culturing urine specimens at 2 h, 4 h, and at 6 h postcollection Recording method: comparison of culture colony counts, and IDs between the different time periods</td>
<td>Type of findings: comparison Effects/findings size: No growth was observed in 53 of the specimens; 47 cultures were positive. Changes in counts exceeding 1 log&lt;sub&gt;10&lt;/sub&gt; or greater were observed in 15 of the specimens. Statistical significance/test: Results/conclusion bias: delays of greater than 2 h in processing specimens may produce results which may cause errors in diagnosis</td>
</tr>
<tr>
<td>Authors: Hindman et al. (30) Title: Effect of Delay on the Culture of Urine Yr: 1976 Publication: J Clin Microbiol Affiliation: Hartford Hospital, Hartford, CT Funding: not reported</td>
<td>Total quality rating (10-point maximum): 6, fair Total for study (3-pt. maximum): 2 (1 point was subtracted as practice was not sufficiently described)</td>
<td>Total for practice (2-pt. maximum): 2</td>
<td>Total for results/findings (3-pt. maximum): 1 (not powered to make large-scale recommendations)</td>
</tr>
<tr>
<td>Design: nonrandomized comparison study Facility/setting: academic medical center Time period: not reported Population/sample: 175 urine specimens collected from patients &lt;2 yr old Comparator: non-preserved urine samples Study bias: criteria for patient selection not given</td>
<td>Description: Samples were collected by midstream void and divided into an unpreserved portion and a portion placed in BA. Duration: 6 h Training: nurses trained on how to split and preserve samples Staff/other resources: not reported Cost: not reported</td>
<td>Description: determination of the ability of boric acid to preserve the quantity and quality of microbial organisms in urine specimens Recording method: comparison of colony counts and organism significance in the 2 portions over 0, 4, 24, and 48 h</td>
<td>Type of findings: comparison Findings/effects size: Unpreserved samples showed fewer positive cultures over time than unprocessed samples; organism IDs were similar in both preserved and unprocessed samples. Statistical significance/test: not reported Results/conclusion bias: limited patients enrolled and only those that were considered to have infections were enrolled</td>
</tr>
<tr>
<td>Authors: Lum and Meers (31) Title: Boric Acid Converts Urine into an Effective Bacteriostatic Transport Medium Yr: 1989 Publication: J Infect Control Affiliation: National University of Singapore, Singapore, China Funding: not reported</td>
<td>Total quality rating (10-point maximum): 6, fair Total for study (3-pt. maximum): 2 (1 selection criteria not well defined)</td>
<td>Total for practice (2-pt. maximum): 2</td>
<td>Total for results/findings (3-pt. maximum): 1 (no statistical analysis, trending data only; no discussion of inhibitory effect of boric acid at time zero)</td>
</tr>
<tr>
<td>Design: cross-sectional Facility/setting: non-teaching hospital Time period: not reported Population/sample: 130 midstream urine samples collected in sterile tubes Comparator: unpreserved urine samples Study bias: no selection criteria indicated</td>
<td>Description: comparison of urine transport using midstream samples shipped without preservative at room temp, on ice, and with boric acid preservative Duration: not reported Training: not reported Staff/other resources: not reported Cost: 0.07 pence/specimen</td>
<td>Description: comparison of results of bacteriological culture and microscopic examination of urine samples transported over a distance either in a dip inoculum transport medium, an ice box, or BA preservative Recording method: results recorded as SG, DS, or NSG</td>
<td>Type of findings: comparison Findings/effects size: BA preserved the ice box-transported urine samples. Findings were similar. Increased numbers of bacteria were found in unpreserved urine compared to numbers in BA-preserved urine Statistical significance/test: not reported Results/conclusion bias: Specimens preserved in BA for &gt;3 days gave misleading results</td>
</tr>
<tr>
<td>Authors: Porter and Brodie (28) Title: Boric Acid Preservation of Urine Samples Yr: 1969 Publication: Br Med J Affiliation: City Hospital, Aberdeen, United Kingdom Funding: not reported</td>
<td>Total quality rating (10-point maximum): 6, fair Total for study (3-pt. maximum): 2 (2 selection criteria not reported)</td>
<td>Total for practice (2-pt. maximum): 2</td>
<td>Total for results/findings (3-pt. maximum): 1 (small sample size, lack of statistical analysis)</td>
</tr>
<tr>
<td>Design: cross-sectional Facility/setting: teaching hospital Time period: not reported Population/sample: 28 urine specimens collected from 643 females and 149 males. 408 were excluded for the following reasons: the time of collection was unknown, they were catheter specimens, the vol was &lt;10 ml, the age of the patient was &lt;16 yr, or the reason was unstated. Comparator: not reported Study bias: none noted</td>
<td>Description: comparison of urine transport using midstream samples shipped without preservative at room temp, on ice, and with boric acid preservative Duration: not reported Training: not reported Staff/other resources: not reported Cost: not reported</td>
<td>Description: comparison of results of bacteriological culture and microscopic examination of urine samples transported over a distance either in a dip inoculum transport medium, an ice box, or BA preservative Recording method: results recorded as SG, DS, or NSG</td>
<td>Type of findings: comparison Findings/effects size: After overnight delayed culture, the results were altered in 16% of samples and the clinical interpretations of these findings differed in 8% of specimens. In 28 samples (3.5%), the bacteria isolated upon initial culture was not the same as that obtained by culture after overnight storage. Statistical significance/test: The difference in the no. of samples for which the interpretation changed from a significant to a nonsignificant culture result after overnight storage and the no. of samples for which the interpretation was altered from a nonsignificant to a significant culture result was clinically significant (odds ratio = 73.80; 95% CI, 41.28 to 133.01). A slight increase from 106 to 117 in the no. of samples recorded as contaminated was also observed; this does not achieve statistical significance (odds ratio = 0.89; 95% CI, 0.66 to 1.20). Results/conclusion bias: none noted</td>
</tr>
<tr>
<td>TABLE A1 (Continued)</td>
<td></td>
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</tr>
<tr>
<td><strong>Bibliographic information</strong></td>
<td><strong>Study</strong></td>
<td><strong>Practice</strong></td>
<td><strong>Outcome measures</strong></td>
</tr>
<tr>
<td>Authors: Guenther and Washington (33)</td>
<td>Design: observational study</td>
<td><strong>Description:</strong> In the first phase, a sample of the specimen was drawn into the BD urine culture kit for transport at room temp, and a sample of the remaining specimen was stored and transported to the laboratory in a sterile tube at 5°C. The samples in both tubes were processed for semiquantitative culture. The BD kit (preserved urine) was stored at room temp and recultured quantitatively after 24 and 48 h. In the second phase, urine was collected into a sterile tube and transported to the laboratory, where it was cultured and then stored under refrigeration. Cultures were examined after incubation for 18 to 24 h. Urine specimens yielding ≥10,000 CFU of bacteria other than <em>Escherichia coli/ml</em> were selected for study by drawing ~5 ml of the refrigerated specimen from a nonsterile paper cup into the BD kit. Cultures of both the original refrigerated specimen and that just drawn into the BD kit were then made within the hour. The BD kit (preserved urine) was then stored at room temp and recultured after 24 and 48 h.</td>
<td><strong>Type of findings:</strong> comparison of colony counts in refrigerated specimens vs specimens stored in BD urine culture kit</td>
</tr>
<tr>
<td>Title: Evaluation of the BD Urine Culture Kit</td>
<td>Facility/setting: academic medical center</td>
<td><strong>Recording method:</strong> routine lab reports</td>
<td><strong>Results/conclusion biases:</strong> BD tubes were missed by MS-2 after being held 24 h, but no statistical analysis performed.</td>
</tr>
<tr>
<td>Yr: 1981</td>
<td>Time period: not reported</td>
<td><strong>Findings/effect size:</strong> In phase 1, 100 samples routinely submitted to the microbiology lab were divided into a refrigeration group and a BD tube group. Colony counts were compared at 0, 5, and 24 h. Samples were also tested using the MS-2 urine screening system. In phase 2, 158 samples known to be positive by routine culture and MS-2 were retested by routine culture and MS-2 at 0 and 24 h. In addition, experiments, MS-2 growth curves are shown for positive samples without and with BD tubes.</td>
<td><strong>Type of findings:</strong> comparison of sensitivity/specificity for routine and BD tube samples</td>
</tr>
<tr>
<td>Publication: J Clin Microbiol</td>
<td>Population/sample: The study was conducted in 2 phases. In both phases, cleanly voided midstream or catheterized urine specimens were collected from patients (no. not specified) suspected of having bacteriuria by a urine collection team.</td>
<td><strong>Description:</strong> In phase 1, 100 samples routinely submitted to the laboratory; phase 2, 158 previously positive samples.</td>
<td><strong>Recording method:</strong> routine lab reports</td>
</tr>
<tr>
<td>Affiliations: Mayo Clinic, Rochester, MN</td>
<td>Comparator: refrigerated urine</td>
<td><strong>Comparison:</strong> refrigerated urine collection team utilized</td>
<td><strong>Statistical significance/tests:</strong> not reported</td>
</tr>
<tr>
<td>Funding: not reported</td>
<td>Study bias: none noted</td>
<td><strong>Cost:</strong> not reported</td>
<td><strong>Type of findings:</strong> comparison of colony counts in refrigerated specimens vs specimens stored in BD urine culture kit</td>
</tr>
</tbody>
</table>

| Authors: Hubbard et al. (34) | Design: nonrandomized comparison | **Description:** In phase 1, 100 samples routinely submitted to the microbiology lab were divided into a refrigeration group and a BD tube group. Colony counts were compared at 0, 5, and 24 h. Samples were also tested using the MS-2 urine screening system. In phase 2, 158 samples known to be positive by routine culture and MS-2 were retested by routine culture and MS-2 at 0 and 24 h. In addition, experiments, MS-2 growth curves are shown for positive samples without and with BD tubes. | **Results/conclusion biases:** no statistical analysis performed. | **Results/conclusion biases:** none noted |
| Title: Comparison B-D Urine Method with a Standard Culture Method and the MS-2 Method | Facility/setting: academic medical center | **Recording method:** routine lab reports | **Type of findings:** comparison of growth rates between refrigerated specimens and BD tube urine samples at 0, 5, and 24 h. | **Type of findings:** comparison of growth rates between refrigerated specimens and BD tube urine samples at 0, 5, and 24 h. |
| Yr: 1983 | Time period: not reported | **Findings/effect size:** Comparison of growth rates were determined for a limited sample of known-positive specimens. | **Type of findings:** comparison of growth rates between refrigerated specimens and BD tube urine samples at 0, 5, and 24 h. | **Type of findings:** comparison of growth rates between refrigerated specimens and BD tube urine samples at 0, 5, and 24 h. |
| Publication: J Clin Microbiol | Population/sample: phase 1, 100 samples routinely submitted to the laboratory; phase 2, 158 previously positive samples. | **Comparison:** refrigerated samples weighted toward positive specimens | **Recording method:** routine lab reports | **Recording method:** routine lab reports |
| Affiliations: University of Michigan Medical Center, Ann Arbor, MI | **Cost:** not reported | **Training:** not reported | **Statistical significance/tests:** not reported | **Statistical significance/tests:** not reported |
| Funding: not reported | Study bias: samples weighted toward positive specimens | **Staff/other resources:** not reported | **Results/conclusion biases:** none noted | **Results/conclusion biases:** none noted |

Total quality rating (10-pt. maximum): 6, fair

Total for study (3-pt. maximum): 1 (BD tube not used as intended; strong bias by using known positive samples)
TABLE A1 (Continued)

| Authors: Lauer et al. (35) | Title: Evaluation of Preservative Fluid for Urine Collected for Culture Yr: 1979 | Publication: J Clin Microbiol Yr: 1979 | Funding: Support provided by a grant from Becton, Dickinson

**Affiliations:** Division of Infectious Diseases and Clinical Microbiology Laboratory, Departments of Pediatrics and Medicine, University of Colorado Medical Center, Denver, CO

**Description:** Each specimen was cultured four times on 5% sheep blood agar and MacConkey agar plates by the surface streak technique with a calibrated 0.001 ml platinum loop at the intervals described below.

1. Each specimen was cultured 0.001 ml platinum loop at the intervals described below.
2. Well-mixed urines plated directly from the sterile container according to routine laboratory procedures served as the initial reference culture (plate 1) for all subsequent comparisons.

3. A portion of urine was poured into a nonsterile, plastic-lined paper cup, drawn into a BD urine culture kit, mixed briefly in a vortex mixer, and recultured (plate 2).
4. The original specimen was refrigerated (4 to 10°C) for 18 to 24 h, and the urine transport tube was left on the laboratory bench at room temp (22 to 24°C) before repeat cultures (plates 3 and 4, respectively).

Duration: not reported
Training: not reported
Staff/other resources: not reported
Cost: not reported

**Total for study (3-pt. maximum): 1 (specimens were not preserved at the point of collection)**

**Total for outcome measures (2-pt. maximum): 2**

**Total for results/findings (3-pt. maximum): 2 (no statistical analysis performed)**

| Authors: Southern and Luttrell (36) | Title: Use of the Becton, Dickinson Urine Culture Tube with the Abbott MS-2 Urine Screening System Yr: 1984 | Publication: Diagn Microbiol Infect Dis Affiliations: Department of Pathology, The University of Texas Health Science Center at Dallas, and Clinical Microbiology Laboratory, Parkland Memorial Hospital, Dallas, TX | Funding: Support provided by Becton, Dickinson

**Affiliations:** Department of Pediatrics and Medicine, University of Colorado Medical Center, Denver, CO

**Description:** All specimens not determined were considered negative. Cultures growing <10³ CFU/ml or a mixture of organisms were considered negative. Colony counts were recorded as >10³, 10³–10⁴, or 10⁴–10⁵ CFU or no growth. A single colony was classified as no growth.

Recording method: not reported

**Total for study (3-pt. maximum): 312**

**Total for practice (2-pt. maximum): 2**

**Total for outcome measures (2-pt. maximum): 2**

**Total for results/findings (3-pt. maximum): 2 (no statistical analysis performed)**

(Continued on following page)
### TABLE A1 (Continued)

| Author: Weinstein (37) Title: Evaluation of Liquid and Lyophilized Preservatives for Urine Culture Yr: 1983 Publication: J Clin Microbiol Affiliations: Departments of Medicine and Pathology, University of Medicine and Dentistry of New Jersey-Rutgers Medical School, and Microbiology Laboratory, Middlesex General University Hospital, New Brunswick, NJ Funding: supported in part by a grant from Becton, Dickinson |
|---|---|---|---|---|
| Design/paired comparative analysis Facility/setting: teaching hospital Time period: not reported Population/sample: A total of 869 midstream clean-catch or catheterized urine specimens were obtained in a sterile cup. 7 specimens were inadvertently discarded after initial plating in the laboratory; thus, there were 862 paired comparisons at 24 h. All urine specimens obtained from inpatients were processed according to the study protocol. Comparator: unpreserved urine samples Study bias: not reported |
| Description: Immediately after a specimen was collected, the responsible nurse obtained 2 samples with a disposable plastic transfer device (BD urine culture kit; Becton, Dickinson Vacutainer Systems). Throughout the study period, 1 sample was obtained in the commercially available Vacutainer tube containing an LQ solution consisting of boric acid, glycerol, and sodium formate. During the latter half of the study period, a second sample was obtained in a Vacutainer tube that contained an LQ similar in content to the LQ, except that sorbitol was substituted for glycerin to facilitate lyophilization. The sterile cup and preserved samples were transported to the laboratory by hospital courier, and an attempt was made in each case to determine the elapsed time between obtaining the specimen and plating it for culture. Duration: 6 mo Training: nurses instructed on urine collection Staff/other resources: not reported Cost: not reported |
| Description: Samples preserved in either LQ or LY were cultured only if they contained ≥0.4 mL of urine. After initial plating (time zero), the sample in the sterile cup was refrigerated (4 to 10°C) for 18 to 24 h; samples preserved in either LQ or LY were kept at room temp in the laboratory (21 to 24°C) for the same period of time. The following morning, all samples were recultured. All isolates obtained from urine cultures growing >10^5 CFU of a single microorganism/mL in pure culture were identified by standard biochemical methods at least to the genus level. Any culture which grew ≤10^5 CFU/mL of a single microorganism in pure culture was considered to be positive for the purpose of data analysis. Recording method: not reported |
| Type of findings: comparison Findings/effect size: 1. At the time of initial plating, 106 of 111 (95.3%) specimens that were positive after conventional transport were also positive in liquid preservative. After a 24-h holding period, agreement was 91.4% (96 of 105). At the time of initial plating, agreement between results obtained by the conventional method and those obtained by using lyophilized preservative was 96.9% (63 of 65); after 24 h, agreement was 92.4% (61 of 67). 2. The proportions of urine cultures showing no change in quantitative growth between the time of initial plating and repeat plating at 24 h were virtually identical for all 3 processing methods (83.6% ± 0.9%). 3. After the 24-h holding period, specimens processed in lyophilized preservative were less likely to show diminished quantitative growth than were specimens processed conventionally or in liquid preservative but were more likely to show an increase in growth of ≥1 log. Nonetheless, the apparent lack of toxicity of lyophilized preservative may make it preferable to the currently available liquid preservative. Statistical significance/certainties: not performed Results/conclusion bias: impact of a >24-h delay in specimen processing was not assessed |
| Total quality rating (10-pt. maximum): 7, fair Total for study (3-pt. maximum): 3 Total for practice (2-pt. maximum): 2 Total for outcome measures (2-pt. maximum): 1 (recording method not reported) Total for results/findings (3-pt. maximum): 1 (no statistical analysis was performed; specimens preserved for longer than 24 h was not assessed) |

**Authors: Wright et al. (32)**

| Design: nonrandomized comparison Facility/setting: academic Time period: not reported Population/sample: Fresh urine and urine preserved in 3 transport systems were tested with 6 separate urine screen systems; specimens were collected from both inpatients and outpatients. Comparator: unpreserved urine Study bias: none noted |
| Description: Preserved urine was screened with 6 urine screen systems: Chemstrip LN, Autobac IDX, BacT Screen, bioluminescence, and the AMS. Fresh specimens received by the laboratory were first quantitatively cultured and screened with the BacT Screen. Screen-positive samples were then added to 3 urine preservation systems, held for 24 h at room temp, and then recultured and retested in each of the 6 urine screens. Duration: not reported Training: not reported Staff/other resources: not reported Cost: not reported |
| Description: 3 commercially available urine transport systems were tested for their effect on rapid urine-screening procedures and organism identifications: a GBF system, a lyophilized SBF system, and a 5.5% BA system. Recording method: not reported |
| Type of findings: comparison Findings/effect size: 1. Quantitative cultures of urine specimens preserved for 24 h showed little or no change in the no. of viable organisms recovered. 2. Quantitative discrepancies ranged from 0% for urine preserved with GBF and tested by AMS or leukocyte esterase to 21% for urine samples in the same preservative tested by bioluminescence or nitrates. 3. Up to 62% of the organism identifications made from preserved urine specimens tested by the AMS urine card were in error. Statistical significance/certainties: not performed Results/conclusion bias: impact of a >24-h delay in specimen processing was not assessed |

Footnote: For scoring information, see Christenson et al. (24). IDs, identifications; pt, point; 95% CI, 95% confidence interval; SG, significant growth; DSG, doubtful significant growth; NSG, nonsignificant growth; LQ, liquid preservative; LY, lyophilized preservative; AMS, Autonomic System; GBF, glycerin-boric acid-sodium formate; SBF, sorbitol-boric acid-sodium formate; BA, boric acid.
TABLE A2 Evidence summary tables for contamination and diagnostic accuracy of urine collected from women

<table>
<thead>
<tr>
<th>Bibliographic information</th>
<th>Total for study</th>
<th>Practice</th>
<th>Outcome measures</th>
<th>Results/findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authors: Blake and Doherty (38)</td>
<td>Design: randomized controlled study</td>
<td>Description: Participants were assigned to either the standard collection group or the sequential collection group. Standard collection group (n = 25) participants were instructed on the collection of an MSCC urine sample. They were told to cleanse their perineum with a towelette, pass the first part of their urine into the toilet, and collect the next part of their urine in a sterile container. Sequential-collection group (n = 25) participants were instructed not to cleanse their perineum and to collect 2 sequential urine samples by voiding 10 to 20 ml into the first container and the remainder into a second sterile container. Midstream urine specimens from both groups were transported to the laboratory for culture. Duration: 2 mo Training: patient instructions given Staff/other resources: not reported Cost: not reported</td>
<td></td>
<td>Type of findings: comparison of colony counts Findings/effect size: 1. No culture grew &gt;10,000 colonies of a pathogenic bacterium. 11 (44%) of the exp1 group samples and 9 (36%) of the control samples grew &gt;10,000 colonies of perinental bacterial flora (chi square = 0.33; P = 0.56). Participants’ previous experience collecting midstream urine was not associated with less bacterial contamination. 2. While the mean rating for comfort with the collection method was higher in the standard collection group than in the sequential-collection group, the mean ratings for ease of collection were not significantly different between groups. 3. A relatively large proportion of cultures showed perineal-flora growth in both the sequential-collection and standard-collection groups, suggesting that perineal cleaning does little to reduce contamination. Statistical significance/tests: chi-square, Fisher’s exact test, and Spearman correlation were used to compare the groups. Data analyses were performed using SPSS for Windows version 12.0 (SPSS Inc. Chicago, IL). Results/conclusion biases: small sample size, use of asymptomatic patients only</td>
</tr>
<tr>
<td>Author: Bradbury (42)</td>
<td>Design: individual randomized control study</td>
<td>Description: Those using the cleaning method were instructed to wash their hands and then use the 3 cotton wool swabs provided to cleanse the genital area with soap and water. They were told to part the labia and wipe from front to back 3 times using a clean swab each time. Keeping the labia parted they passed some urine into the toilet and then caught some urine in a sterile container containing 0.4 g of boric acid as a preservative. Participants not using the cleaning method were instructed simply to pass some urine into the toilet, stop and then catch the next urine in a sterile BA container Duration: 16 mo Training: each patient was given written collection instructions Staff/other resources: not reported Cost: not reported</td>
<td>Description: Samples were evaluated by standard microbiological techniques and classified as definitive or equivocal infection based on the quantity of microorganisms Recording method: routine laboratory reports</td>
<td>Type of findings: comparison of culture results, calculation of contamination rates Findings/effect size: A total of 316 specimens, 158 from women with symptoms of cystitis and 158 from asymptomatic controls, were examined. No significant differences were found in the numbers of contaminated or unreliable results between the specimens collected with and those collected without preparatory cleansing. Statistical significance/tests: not reported Results/conclusion biases: none reported</td>
</tr>
<tr>
<td>Title: Collection of Urine Specimens in General Practice To Clean or Not To Clean? Yr: 1988 Publication: J R Coll Gen Pract</td>
<td>Design: individual randomized control study</td>
<td>Facility/setting: S-physician private-practice setting Time period: not reported</td>
<td>Population/sample: A total of 316 urine specimens were collected from 158 female patients suspected of having UTIs and from 158 controls. The study group comprised any female aged 16–75 yr who presented with symptoms of frequency and dysuria. The control group comprised the next nonpregnant female attending the surgery with no urinary tract symptoms. The women were randomly allocated to 1 of the 2 methods of urine collection. Comparator: clean-catch collections Study bias: control group without symptoms of UTI</td>
<td></td>
</tr>
<tr>
<td>Affiliations: General Practitioner, Stoke-on-Trent and Research Fellow, Department of Postgraduate Medicine, University of Keele, United Kingdom Funding: funded by a grant from the Research Advisory Committee of the North Staffordshire Medical Institute</td>
<td>Total quality rating (10-pt. maximum): 7, fair</td>
<td>Total for study (3-pt. maximum): 1 (selection of control group, generalizability)</td>
<td>Total for practice (2-pt. maximum): 2</td>
<td>Total for outcome measures (2-pt. maximum): 2</td>
</tr>
</tbody>
</table>

(Continued on following page)
### TABLE A2 (Continued)

<table>
<thead>
<tr>
<th>Authors: Holliday et al. (39)</th>
<th>Title: Perineal Cleansing and Midstream Urine Specimens in Ambulatory Women</th>
<th>Yr: 1991</th>
<th>Funding: not reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design: randomized comparison study</td>
<td>Description: Sterile packs were used for all specimens. Noncleansing patients were instructed in the use of the pack only. Cleansing patients received the same information but additionally were asked to clean the genital area with sterile gauze swabs soaked in sterile normal saline and used with a single backwards stroke before finally drying the area with another sterile gauze swab.</td>
<td>Practice:</td>
<td>Outcome measures:</td>
</tr>
<tr>
<td>Description:</td>
<td>Recording method: routine laboratory reports</td>
<td>Comparison of urine microcopy and culture results stratified by colony count in each group</td>
<td>Type of findings: comparison of culture results</td>
</tr>
</tbody>
</table>

### TABLE A2 (Continued)

<table>
<thead>
<tr>
<th>Authors: Schlager et al. (40)</th>
<th>Title: Perineal Cleansing Does Not Reduce Contamination of Urine Samples from Pregnant Adolescents</th>
<th>Yr: 1999</th>
<th>Publication: Pediatr Infect Dis J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design: nonrandomized comparison study</td>
<td>Description: Each subject gave 2 urine samples during consecutive urinations in 1 routine prenatal visit; the first was by midstream collection, the second by clean-catch collection. Urine samples were refrigerated immediately after collection, plated within 5 h of collection, and cultured by routine microbiological techniques.</td>
<td>Practice:</td>
<td>Outcome measures:</td>
</tr>
<tr>
<td>Description:</td>
<td>Recording method: routine laboratory reports</td>
<td>Significant bacteriuria was defined as $&gt;10^5$ CFU/ml of urine. Lower counts were considered contaminants. Results were analyzed for mean differences in colony counts between the 2 methods of collection.</td>
<td>Type of findings: comparative differences in the numbers and types of microorganisms</td>
</tr>
</tbody>
</table>

### TABLE A2 (Continued)

<table>
<thead>
<tr>
<th>Authors: Schneeberger et al. (43)</th>
<th>Title: Contamination Rates of Three Urine-Sampling Methods To Assess Bacteriuria in Pregnant Women</th>
<th>Yr: 2013</th>
<th>Publication: Obstet Gynecol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design: cross-sectional</td>
<td>Description: 3 methods of collection were compared for differences in Gram stain, leukocyte, esterase and nitrate dip stick, and culture results.</td>
<td>Practice:</td>
<td>Outcome measures:</td>
</tr>
<tr>
<td>Facility/setting: outpatient obstetrics clinic</td>
<td>Duration: 12 mo</td>
<td>Recording method: routine laboratory reports</td>
<td>Type of findings: comparison</td>
</tr>
<tr>
<td>Time period: April 2010–April 2011</td>
<td>Training: oral and written sampling instructions were provided to each patient.</td>
<td>Recording method: not reported</td>
<td>savings of $$97,560/yr if clean-catch practices were stopped</td>
</tr>
<tr>
<td>Population/sample: convenience sample of 113 pregnant women who had had 3 different midstream urine samples collected consecutively: first void, midstream without cleansing, and midstream clean-catch.</td>
<td>Staff/other resources: nursing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparator: midstream sample used as reference test. Study bias: sample size too small to detect some differences in collection technique.</td>
<td>Cost: a potential cost savings of $97,560/yr if clean-catch practices were stopped</td>
<td>Results/conclusion biases: results may apply only to ambulatory prenatal patients</td>
<td></td>
</tr>
</tbody>
</table>

(Continued on following page)
### TABLE A2 (Continued)

<table>
<thead>
<tr>
<th>Bibliographic information</th>
<th>Total for study (3-pt. maximum): 2 (sample size)</th>
<th>Practice</th>
<th>Outcome measures</th>
<th>Results/findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total quality rating (10-pt. maximum): 7, fair</td>
<td>Total for study (3-pt. maximum): 10</td>
<td>Total for practice (2-pt. maximum): 2</td>
<td>Total for outcome measures (2-pt. maximum): 1 (recording method not reported)</td>
<td>Total for results/findings (3-pt. maximum): 2 (nearly 100% of samples yielded contaminants)</td>
</tr>
</tbody>
</table>

**Authors:** Walter and Knopp (41)  
**Title:** Urine Sampling in Ambulatory Women: Midstream Clean-Catch versus Catheterization  
**Yr:** 1986  
**Publication:** Can Med Assoc J  
**Affiliations:** Department of Emergency Medicine, Valley Medical Center, Fresno, CA, and Departments of Medicine and Family and Community Medicine, University of California, San Francisco, CA  
**Funding:** supported in part by a grant from Hoffman La Roche Limited  
**Affiliations:** Research Committee of Valley Medical Center, Fresno, CA  

**Design:** nonrandomized comparison study  
**Facility/setting:** teaching hospital  
**Time period:** May–November 1986  
**Population/sample:** 105 consecutive women  
**Selection criteria:** included any ambulatory adult woman or legally emancipated female minor who presented to the Emergency Department  
**Comparator:** catheterized urine sample  
**Study bias:** ED patients only  

**Description:** Each patient spread her labia, prepped her perineal area by wiping 3 providone-iodine-soaked 4- by 4-in. gauzes in an anterior-to-posterior direction, and spontaneously voided a midstream clean-catch urine sample. Then, the patient was immediately steriley prepped with providone-iodine and catheterized by a nurse using a Davol single-use female catheterization kit.  
**Duration:** 7 no  
**Training:** Patients received standardized verbal instructions from a nurse on the method for MSCC urine collection  
**Staff/other resources:** not reported  
**Cost:** not reported  

**Type of findings:** comparison  
**Findings/effect size:** Of the 105 patients, 42 (40%) had a culture-proven UTI. The concordance rates between MSCC and CATH urine cultures, nitrites, leukocyte esterase, significant microscopic bacteriuria, and pyuria were 96%, 94%, 93%, 99%, and 90%, respectively. There were no statistically significant differences between MSCC and catheterized specimens for sensitivities, specificities, or positive or negative predictive values for any urinalysis variable (leukocyte esterase, nitrites, significant microscopic bacteriuria, or pyuria).  
**Statistical significance/tests:** McNemar’s test, Fischer’s exact test, and power analysis. Two-tailed statistical tests were performed.  
**Results/conclusion biases:** Findings were limited to ambulatory women who have 1 or more symptoms compatible with a UTI and were specifically instructed in the proper technique of MSCC urine sampling.  

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**Authors:** Lemieux and St.-Martin (45)  
**Title:** Reliability of Clean-Voided Midstream Urine Specimens for the Diagnosis of Significant Bacteriuria in the Female Patient  
**Yr:** 1986  
**Publication:** Can Med Assoc J  
**Affiliations:** Renal Laboratory and Renal Clinic Montreal School of Medicine; Department of Bacteriology, Hotel-Dieu Hospital, Montreal, Canada  
**Funding:** supported in part by a grant from Hoffman La Roche Limited  

**Design:** cross-sectional  
**Facility/setting:** teaching hospital  
**Time period:** not reported  
**Population/sample:** 3 groups of patients were studied. Group 1 consisted of 53 healthy student nurses (aged 18 to 23 yr; mean, 19 yr) having a first morning cleanly voided midstream specimen collected. Group 2 consisted of 29 female patients admitted to a general medical female ward service (aged 21 to 53 yr; mean, 42 yr) with both clean-void and catheterized urine specimens collected at the same time. Group 3 consisted of 27 female patients (aged 24 to 54 yr; mean, 43 yr) admitted to either a semiprivate or general medical ward. Both cleanly voided and catheterized specimens were collected at the same time.  
**Comparator:** not reported  
**Study bias:** none noted  

**Description:** All specimens were collected in the same room by the same 2 nurses. Both the nurses and patients wore sterile rubber gloves during the entire sampling process. The perineum was cleaned with soap and water and dried with a paper towel. The labia were separated and the vulva was washed with green soap, with a fresh cotton swab used after each downward stroke. The same maneuver was repeated with an aqueous solution of Zephiran (benzalkonium; 1:1,000). The subjects were then instructed to void after separating the labia majora. After the stream was well started, a sterile screw-cap jar was placed into the path of the stream and a small sample of urine collected. Subjects from whom paired specimens were obtained were told to stop voiding as soon as the cleanly voided specimen was obtained. A sterile rubber French no. 8 catheter lubricated with a small amount of sterile lubricant was then inserted into the urethra, and a final specimen was collected in another screw-cap jar. The specimens were taken immediately to the laboratory, where they were processed for bacterial counts, routine bacterial identification, and Gram staining.  
**Duration:** not reported  
**Training:** 2 graduate nurses were trained to collect both cleanly voided and catheterized specimens.  
**Staff/other resources:** not reported  
**Cost:** not reported  

**Type of findings:** comparative colony counts  
**Findings/effect size:** In group 1, the cleanly voided urine samples contained no bacteria after 48 h in 46 (87%) of the 53 subjects. In group 2, the incidence of sterile cleanly voided urine samples was also quite high (69%), while not a single catheterized specimen showed bacterial growth after 48 h. In group 3, a very high degree of correlation was found between cleanly voided and catheterized specimens with regard to both the type of organism and the bacterial counts  
**Statistical significance/tests:** not reported  
**Results/conclusion biases:** not reported  

(Continued on following page)
### TABLE A2 (Continued)

<table>
<thead>
<tr>
<th>Bibliographic information</th>
<th>Total for study</th>
<th>Practice</th>
<th>Outcome measures</th>
<th>Results/findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authors: Immergut et al.</td>
<td>Design: nonrandomized comparison</td>
<td>Description: Patients were asked to urinate in private without any prep. They collected the urine at any time during voiding in an sterile disposable plastic cup. The specimens were immediately cultured on Uricult media by dipping the slides into the plastic cups. Routine chemical and microscopic analysis of the urine was performed on each specimen. A cystoscopic examination was performed with an instrument which had been soaked for at least 10 min in Cidex solution and then rinsed in sterile water. Urine specimens obtained through the cystoscope were similarly cultured on Uricult slides. Duration: not reported Training: not reported Staff/other resources: not reported Cost: not reported</td>
<td>Total for practice (2-pt. maximum): 2</td>
<td>Total for outcome measures (2-pt. maximum): 1</td>
</tr>
<tr>
<td>Title: The Myth of the Clean-Catch Urine Specimen</td>
<td>Facility/setting: physician office practice Time period: not reported Population/sample: 95 ambulatory female patients Comparator: cystoscopic specimen collection Study bias: none noted</td>
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<td></td>
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<tr>
<td>Yr: 1981</td>
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<tr>
<td>Publication: Urology</td>
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</tr>
<tr>
<td>Affiliations: not reported</td>
<td></td>
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<td></td>
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<tr>
<td>Funding: not reported</td>
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</tr>
</tbody>
</table>

*MSCC, midstream clean-catch collection; CATH, catheterization; HPF, high-power field.*
### Table A3: Evidence summary table for contamination and diagnostic accuracy of urine collected from men

<table>
<thead>
<tr>
<th>Bibliographic information</th>
<th>Total for study</th>
<th>Practice</th>
<th>Outcome measures</th>
<th>Results/findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Authors:</strong> Lipsky et al. (46)</td>
<td>Design: group randomized control study</td>
<td>Description: Subjects were directed to collect paired voided urine specimens for culture. Those whose Social Security numbers ended in an even digit were instructed to cleanse their glans penis with a povidone-iodine pad before voiding. Persons with odd Social Security numbers served as noncleanse control subjects. Patients in both groups collected 10 to 20 ml of “initial” and “midstream” specimens by passing the first part of the voided urine into a sterile cup, discarding the next 100 to 200 ml of urine into the urinal, and then collecting a second aliquot of urine in another sterile container. All specimens were immediately refrigerated at 4°C and delivered within 4 hours to the clinical microbiology laboratory for Gram staining and semiquantitative culture. Organisms were identified using standardized techniques. Nonhemolytic streptococci were characterized as viridans streptococci or enterococci. All other organisms were identified to the species level. Duration: 7 mo Training: A graphic instructional sign displaying the clean-void procedure was posted in the bathroom where the samples were collected. Staff/other resources: A technician was available to patients needing assistance. Cost: not reported</td>
<td>Description: A “positive” culture was defined as one with growth of 1,000 or more CFU/ml of a single or predominant organism. Specimens growing 1,000 CFU/ml of a single or predominant organism were called “indeterminate.” Those with 1,000 or more CFU/ml with 2 or more colonial types and with no predominant organism were defined as “contaminated.” Specimens growing less than 1,000 CFU/ml were considered “negative.” Recording method: routine laboratory reports</td>
<td>Type of findings: comparison Findings/effect size: The rates of true bacteriuria and contamination were compared in the various collection technique subgroups. Neither the bacteriuria nor contamination rates were significantly different (P &gt; 0.05) in circumcised and uncircumcised patients, or in those who cleansed their meatus and those who did not. Contamination but not bacteriuria rates were higher in initial than in midstream specimens. Statistical significance/tests: Statistical analysis for evaluating meatal cleansing and circumcision status was by the standard chi-square technique and by McNemar’s test for paired data for evaluating collection timing. A P value of &lt;0.05 was considered significant. Results/conclusion biases: none noted</td>
</tr>
<tr>
<td>Authors: Lipsky et al. (47)</td>
<td>Design: observational study</td>
<td>Description: Specimens were collected in the following order: suprapubic aspiration or urethral catheterization and I voided (uncleansed first void or clean-catch midstream void) specimens were collected from every subject. Duration: not reported Training: not reported Staff/other resources: not reported Cost: not reported</td>
<td>Description: Specimens were cultured by standard microbiological techniques; urine leukocytes were quantitated with a hemacytometer. Plates were examined after incubation for 18–24 h. Isolates from plates with fewer than 3 different colonial types were identified to the species level. Urine leukocytes were quantitated (in cells/mm³) of uncentrifuged urine) in a hemacytometer. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated for results of culture of the uncleaned first-void and clean-catch midstream-void specimens, with bladder specimens used as the reference standard. Recording method: not reported</td>
<td>Type of findings: comparison Findings/effect size: Bladder bacteriuria was found in 36 of 76 sets of specimens from 66 individuals. Culture results of bladder specimens showed excellent agreement with that of clean-catch midstream-void and uncleaned first-void specimens. The criterion for clean-catch midstream-void specimens that best differentiated sterile from infected bladder urine was the growth of &gt;1,000 CFU/ml of 1 predominant species. Uncleaned first-void specimens were equally sensitive (0.97) but less specific (0.91–0.92) in detection of bacteriuria. Pyuria (&gt;1,000 leukocytes/mm³) and irritative genitourinary symptoms showed modest correlations with bladder bacteriuria.</td>
</tr>
</tbody>
</table>

**Total quality rating (10-pt. maximum):** 9, good

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2 (only urology clinic patients included)</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**Authors:** Diagnosis of Bacteriuria in Men: Specimen Collection and Culture Interpretation

Yr: 1987

**Publication:** J Infect Dis

**Affiliations:** Departments of Medicine and Urology, University of Washington School of Medicine, and Medical and Surgical Services, Seattle VA Medical Center, Seattle, WA

**Funding:** not reported

**Design:** observational study

Facility/setting: VA medical center

Time period: not reported

Population/sample: 66 ambulatory or hospitalized male patients who had acute dysuria or other irritative genitourinary symptoms, were known to have bacteriuria, or were scheduled for a urologic procedure. Individuals were excluded because of an inability to void at will, use of any type of internal or external device for urine collection, massive obesity, previous lower abdominal surgery or radiation therapy, known or suspected bladder neoplasm, or any coagulation disorder.

Comparator: urine collected by suprapubic aspiration

Study bias: subjects were not randomly selected.

**Description:** Specimens were collected in the following order: suprapubic aspiration or urethral catheterization and I voided (uncleaned first void or clean-catch midstream void) specimens were collected from every subject. Duration: not reported Training: not reported Staff/other resources: not reported Cost: not reported

**Description:** Specimens were cultured by standard microbiological techniques; urine leukocytes were quantitated with a hemacytometer. Plates were examined after incubation for 18–24 h. Isolates from plates with fewer than 3 different colonial types were identified to the species level. Urine leukocytes were quantitated (in cells/mm³) of uncentrifuged urine) in a hemacytometer. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated for results of culture of the uncleaned first-void and clean-catch midstream-void specimens, with bladder specimens used as the reference standard. Recording method: not reported

**Type of findings: comparison**

Findings/effect size: Bladder bacteriuria was found in 36 of 76 sets of specimens from 66 individuals. Culture results of bladder specimens showed excellent agreement with that of clean-catch midstream-void and uncleaned first-void specimens. The criterion for clean-catch midstream-void specimens that best differentiated sterile from infected bladder urine was the growth of >1,000 CFU/ml of 1 predominant species. Uncleaned first-void specimens were equally sensitive (0.97) but less specific (0.91–0.92) in detection of bacteriuria. Pyuria (>1,000 leukocytes/mm³) and irritative genitourinary symptoms showed modest correlations with bladder bacteriuria.

(Continued on following page)
<table>
<thead>
<tr>
<th>Bibliographic information</th>
<th>Total for study</th>
<th>Practice</th>
<th>Outcome measures</th>
<th>Results/findings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Statistical significance/tests: Agreement between bladder and voided specimens was tested with use of a weighted $k$ statistic with 95% CIs.</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>Results/conclusion biases: Study participants were not consequtively or randomly selected but were a heterogeneous group of mostly elderly ambulatory men with various genitourinary disorders. When a positive culture is used for screening or in populations with a low incidence of bacteriuria, the predictive value of a positive culture will be less than in this study.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total for results/findings (3-pt. maximum): 2 (higher pretest probability than found in general patient population)</td>
<td></td>
</tr>
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**Total quality rating (10-pt. maximum): 7, fair**

Total for study (3-pt. maximum): 2 (selection bias)  
Total for practice (2-pt. maximum): 2  
Total for outcome measures (2-pt. maximum): 1 (recording method not reported)  
Total for results/findings (3-pt. maximum): 2

**Authors:** Deresinski and Perkash (48)  
**Title:** Urinary Tract Infections in Male Spinal Cord Injured Patients. Part One: Bacteriologic Diagnosis  
**Yr:** 1985  
**Publication:** J. Am. Paraplegia Soc.  
**Affiliations:** Spinal Cord Injury Service VA and Stanford University Medical Centers Palo Alto, CA  
**Funding:** not reported

Total for study (3-pt. maximum): 2 (the total for the study population is not sufficiently described)  
Total for practice (2-pt. maximum): 1 (poor description of practice)  
Total for outcome measures (2-pt. maximum): 1 (recording method not described)  
Total for results/findings (3-pt. maximum): 1

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LaRocco et al.
TABLE A4 Evidence summary table for contamination and diagnostic accuracy of urine collected from children

<table>
<thead>
<tr>
<th>Authors: Karacan et al. (33)</th>
<th>Authors: Alam et al. (53)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title: Evaluation of Urine Collection Methods for the Diagnosis of Urinary Tract Infection in Children</td>
<td>Title: Comparison of Urine Contamination Rates Using Three Different Methods of Collection: Clean-catch, Cotton Wool Pad, and Urine Bag</td>
</tr>
<tr>
<td>Yr: 2010</td>
<td>Yr: 2005</td>
</tr>
<tr>
<td>Publication: Med Princ Pract</td>
<td>Publication: Ann Trop Pediatr</td>
</tr>
<tr>
<td>Affiliations: Department of Pediatrics, Dr. Sami Ulas Children’s Hospital, Ankara, Turkey</td>
<td>Affiliations: Liverpool School of Tropical Medicine, Liverpool United Kingdom; Instituto Materno Infantil de Pernambuco, Recife, Brazil</td>
</tr>
<tr>
<td>Funding: not reported</td>
<td>Funding: not reported</td>
</tr>
</tbody>
</table>

**Bibliographic information**

- Authors: Karacan et al. (33)
- Title: Evaluation of Urine Collection Methods for the Diagnosis of Urinary Tract Infection in Children
- Yr: 2010
- Publication: Med Princ Pract
- Affiliations: Department of Pediatrics, Dr. Sami Ulas Children’s Hospital, Ankara, Turkey
- Funding: not reported

**Bibliographic information**

- Authors: Alam et al. (53)
- Title: Comparison of Urine Collection Methods for the Diagnosis of Urinary Tract Infection in Children
- Yr: 2010
- Publication: Med Princ Pract
- Affiliations: Department of Pediatrics, Dr. Sami Ulas Children’s Hospital, Ankara, Turkey
- Funding: not reported

**Design**: cross-sectional

- Facility/setting: teaching hospital
- Time period: not reported

Population/sample: 1,067 children, 88 younger than 1 mo, 326 between 1 and 6 mo, 318 between 7 and 24 mo, and 535 older than 24 mo of age. There were 521 (48.9%) girls. Of these 1,067 children, 951 (89.1%) were admitted to the outpatient clinic and 116 (10.9%) were admitted to the inpatient clinic.

**Comparator**: none

- Study bias: none noted

**Description**: 4 methods of urine collection were studied: SPA, CCU, CATH, and UB.

- Duration: 2 mo
- Training: Nurses trained parents on UB collection. Hospital personnel were trained on proper collection of SPA and CATH specimens.
- Staff/other resources: not reported
- Cost: not reported

**Design**: prospective cross-sectional

- Facility/setting: teaching hospital
- Time period: not reported

Population/sample: Children aged up to 3 yr without known UTI had urine collected by 3 different methods used consecutively, namely, clean-catch, cotton wool sanitary pad, and urine bag. 534 urine samples were obtained from 191 children. There were 124 boys (65%). The median age was 2 mo (1 d–36 mo).

- Comparator: intersubject study bias: order of specimen collection not defined

- Training: parents instructed by nursing on proper urine collection.
- Staff/other resources: not reported
- Cost: cost of pads described

**Description**: 3 urine samples collected after perineal cleaning with soap and water (all 3 collected on same day or next day if required, with the order of collection at the nurses’ discretion). The 1st was a clean-catch specimen, the 2nd was collected in a cotton pad (either sterile Newcastle or commercial sanitary pads) and aspiration with a syringe. The 3rd was collected in a Hollister urine bag taped to the infant. Samples were held in a refrigerator, transferred to sterile coded tubes, and plated within 20 min of receipt by the laboratory. Cultures were interpreted as >10^5 or <10^5 CFU/ml. Also, microscopy was performed on uncentrifuged urine.

- Duration: 2 mo

**Design**: cross-sectional

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- Time period: not reported

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- Comparator: intersubject study bias: order of specimen collection not defined

- Training: parents instructed by nursing on proper urine collection.
- Staff/other resources: not reported
- Cost: cost of pads described

Description: The specimens collected by type were divided according to age group. The no. of specimens yielding significant pathogens and the no. of contaminated specimens were calculated. Semiquantitative cultures were performed by routine laboratory methods. A positive urine culture was defined as the growth of a single pathogen of more than 10^5 CFU/ml in UB and CCU specimens, >10^4 CFU/ml in urine specimens obtained by CATH, and any no. of colonies in a sample obtained by SPA. Urine cultures interpreted as “contaminated” by the laboratory were considered to be contaminated. Recording method: not reported

**Description**: 3 urine samples collected after perineal cleaning with soap and water (all 3 collected on same day or next day if required, with the order of collection at the nurses’ discretion). The 1st was a clean-catch specimen, the 2nd was collected in a cotton pad (either sterile Newcastle or commercial sanitary pads) and aspiration with a syringe. The 3rd was collected in a Hollister urine bag taped to the infant. Samples were held in a refrigerator, transferred to sterile coded tubes, and plated within 20 min of receipt by the laboratory. Cultures were interpreted as >10^5 or <10^5 CFU/ml. Also, microscopy was performed on uncentrifuged urine.

- Duration: 2 mo

Training: parents instructed by nursing on proper urine collection.
- Staff/other resources: not reported
- Cost: cost of pads described

Description: The percentage of urine samples contaminated by each collection method was based on a quantity of >10^5 or <10^5 CFU/ml, organism type, and agreement between sample types. Phase-contrast urine microscopy results were correlated with culture results.

Recording method: not reported

**Type of methods: descriptive, comparative**

- Findings/size: Results from 175 patients showed similar contamination rates for pads and bags but lower rates for clean-catch specimens (P < 0.001). Kappa analysis showed fair agreement between clean-catch specimens and those collected in pads/bags. The difference between sterile pads and sanitary pads was not significant. No significant differences were based on gender. Microscopy showed reasonable correlation with culture positivity.

- Statistical significance/tests: agreement between the tests calculated using kappa statistics. More than 40% agreement was regarded as a good level of agreement. The chi-square test was used to analyze differences in proportions.

**Results/conclusion biases: results limited to nonsymptomatic pediatric inpatients**

**TABLE A4 Evidence summary table for contamination and diagnostic accuracy of urine collected from children**

<table>
<thead>
<tr>
<th>Test bias: none noted</th>
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<tbody>
<tr>
<td>Comparator: none</td>
<td>Comparator: none</td>
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<tr>
<td>Time period: not reported</td>
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<tr>
<td>Facility/setting: teaching hospital</td>
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Design: cross-sectional

- Facility/setting: teaching hospital
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Population/sample: 1,067 children, 88 younger than 1 mo, 326 between 1 and 6 mo, 318 between 7 and 24 mo, and 535 older than 24 mo of age. There were 521 (48.9%) girls. Of these 1,067 children, 951 (89.1%) were admitted to the outpatient clinic and 116 (10.9%) were admitted to the inpatient clinic.

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- Study bias: none noted

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- Duration: 2 mo
- Training: Nurses trained parents on UB collection. Hospital personnel were trained on proper collection of SPA and CATH specimens.
- Staff/other resources: not reported
- Cost: not reported

**Design**: prospective cross-sectional

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- Time period: not reported

Population/sample: Children aged up to 3 yr without known UTI had urine collected by 3 different methods used consecutively, namely, clean-catch, cotton wool sanitary pad, and urine bag. 534 urine samples were obtained from 191 children. There were 124 boys (65%). The median age was 2 mo (1 d–36 mo).

- Comparator: intersubject study bias: order of specimen collection not defined

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Description: The percentage of urine samples contaminated by each collection method was based on a quantity of >10^5 or <10^5 CFU/ml, organism type, and agreement between sample types. Phase-contrast urine microscopy results were correlated with culture results.

Recording method: not reported

**Type of methods: descriptive, comparative**

- Findings/size: Results from 175 patients showed similar contamination rates for pads and bags but lower rates for clean-catch specimens (P < 0.001). Kappa analysis showed fair agreement between clean-catch specimens and those collected in pads/bags. The difference between sterile pads and sanitary pads was not significant. No significant differences were based on gender. Microscopy showed reasonable correlation with culture positivity.

- Statistical significance/tests: agreement between the tests calculated using kappa statistics. More than 40% agreement was regarded as a good level of agreement. The chi-square test was used to analyze differences in proportions.

**Results/conclusion biases: results limited to nonsymptomatic pediatric inpatients**

(Continued on following page)
### TABLE A4 (Continued)

<table>
<thead>
<tr>
<th>Bibliographic information</th>
<th>Total for study (10-pt. maximum): 8, good</th>
<th>Total for practice (2-pt. maximum): 2</th>
<th>Total for outcome measures (2-pt. maximum): 1 (recording method not described)</th>
<th>Total for results/findings (3-pt. maximum): 2 (limited patient population)</th>
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<tbody>
<tr>
<td>Authors: Macfarlane et al. (54)</td>
<td>Total for study (3-pt. maximum): 3</td>
<td>Total for practice (2-pt. maximum): 2</td>
<td>Description: 1. The UCP was placed inside the front of the child's nappy; the child’s nurse checked the pad every 15–20 min, removed it when wet, and aspirated urine from it using a 20-ml syringe. Fecally soiled pads were discarded. 2. Urine from 34 children in the same age range and ward setting that had bag urine collection done over the preceding 9 mo was similarly tested. Duration: 3 mo Training: not reported Staff/other resources: not reported Cost: not reported</td>
<td>Type of findings: observational/comparative Findings/effect size: UCPs resulted in an unhelpfully high rate of contamination (65%) similar to that for bag samples (60%). Only 27% of clean-catch urine samples were contaminated. Sterile urine or urine with a low (&lt;10^5 CFU/ml) mixed bacterial count is probably sufficient in most cases to rule out UTI, whereas a sample contaminated by a heavy mixed growth may hide infection. Such samples may need to be repeated. Applying this principle to our series, the authors found that 14 (27%) of 52 pad samples, 11 (32%) of 34 bag samples, but only 29 (12%) of 240 clean-catch samples would have been repeated. Statistical significance/tests: Results/conclusion biases: not reported</td>
</tr>
<tr>
<td>Title: Pad Urine Collection for Early Childhood Urinary Tract Infection Yr: 1999 Publication: Lancet Affiliations: Departments of Child Health and Microbiology, Rotherham General Hospital, Rotherham, United Kingdom Funding: not reported</td>
<td>Design: observational Facility/setting: teaching hospital Time period: not reported Population/sample: 1. 88 inpatients, all below 2 yr of age, were included. 56 UCP samples were reliably obtained; the remaining 32 samples failed for a variety of reasons and were excluded. 2. 34 children in the same age range had urine bag collection done over the preceding 9 mo. 3. 240 clean-catch samples were analyzed (no. of children not reported) Comparator: between-patient populations Study bias: nonrandom, unequal sample sizes, no standard reference method</td>
<td>Description:</td>
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<table>
<thead>
<tr>
<th>Authors: Ahmad et al. (55)</th>
<th>Total for study (3-pt. maximum): 3 (different patient populations and sizes, no reference standard)</th>
<th>Total for practice (2-pt. maximum): 1 (limited practice description)</th>
<th>Total for outcome measures (2-pt. maximum): 1 (recording method not reported)</th>
<th>Total for results/findings (3-pt. maximum): 2 (no statistical analysis)</th>
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<tbody>
<tr>
<td>Title: Urine Collection from Disposable Nappies Yr: 1991 Publication: Lancet Affiliations: Department of Child Health and Department of Microbiology, Royal Victoria Infirmary, Newcastle upon Tyne, United Kingdom Funding: not reported</td>
<td>Design: prospective cross-sectional Facility/setting: hospital Time period: not reported Population/sample: 2 urine samples, collected from 45 infants aged 1–23 mo, 1 with a sterile bag and 1 from a nongel diaper Comparator: bag vs diaper Study bias: only inpatients included in study, small sample size</td>
<td>Description: 2 consecutive urine samples were collected from 45 infants who were 1–23 mo old: 1 from a sterile urine bag and 1 from a nongel diaper. Diapers older than 4 h and containing feces were excluded. WBC and RBC evaluations were performed using microscopy. All specimens were processed for routine culture by the microbiology laboratory. Duration: not reported Training: not reported Staff/other resources: not reported Cost: not reported</td>
<td>Description: semiquantitative culture with standard definitions for contamination and significance (&gt;10^5 CFU/ml) Recording method: not reported</td>
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<td>Type of findings: comparative Findings/effect size: 255 urine cultures showed complete agreement between the 2 collection techniques (22 sterile urine samples, 9 mixed cultures, 6 with significant growth), 7 infants had mixed growth from bag specimens but sterile culture results from diaper specimens. 1 infant had &gt;10^5 CFU/ml of different organisms in the bag specimen vs the diaper specimen. Statistical significance/tests: not reported Results/conclusion biases: none noted</td>
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</table>

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(Continued on following page)
TABLE A4 (Continued)

<table>
<thead>
<tr>
<th>Authors/Institutions</th>
<th>Practice</th>
<th>Outcome measures</th>
<th>Results/findings</th>
</tr>
</thead>
</table>
| Funding: not reported | **Source:** Australian Paediatric Surveillance Unit (APSU), Department of Paediatrics, Monash University, Melbourne, Australia. Study design: observational, retrospective study. **Population/sample:** all children aged 0–5 years admitted to the hospital with a urinary tract infection (UTI). **Comparator:** clean-catch urine specimen. **Recording:** lab database. **Statistical analysis:** multivariable Poisson regression with robust standard errors.

**Results/findings:** The risk for a positive urine culture result was significantly higher in the non-cleaning group (OR 3.8; 95% CI, 2.0–7.0) compared to the cleaning group. The rate of positive urine cultures was 31% in the non-cleaning group vs 20% in the cleaning group (p < 0.05). This difference was statistically significant and persisted after adjustment for potential confounders including age, gender, location, history of UTIs, circumcision status, and antibiotic use at time of specimen collection.

**Discussion:** The results of this study highlight the importance of proper urine collection techniques to reduce contamination rates and improve diagnostic accuracy. The use of clean-catch urine specimens during routine urinalysis is recommended to minimize contamination and enhance the reliability of diagnostic test results.
<table>
<thead>
<tr>
<th>Bibliographic information</th>
<th>Total for study</th>
<th>Practice</th>
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<tr>
<td>Funding: not reported</td>
<td></td>
<td>Cost: not reported</td>
<td></td>
<td>3. 369 medical records were available for review. 5% of patients had had prior UTIs, 14% were receiving antibiotics when the specimen had been obtained, and 11% had a known urogenital abnormality. Only antibiotic use at the time of urine collection was associated with a lower contamination rate (OR, 0.18; 95% CI, 0.04–0.75). Results by multivariable logistic regression when adjusted for age, gender, patient location, and antibiotic use were similar. Statistical significance/tests: Logistic regression was used to compare contamination rates between collection methods, using CCU as the comparator for ORs. Statistical calculations were performed using Stata 11.0 (Stata Corp., College Station, TX).</td>
</tr>
<tr>
<td>Authors: Morton and Lawande (37)</td>
<td></td>
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<td></td>
<td>Statistical significance/tests: Logistic regression was used to compare contamination rates between collection methods, using CCU as the comparator for ORs. Statistical calculations were performed using Stata 11.0 (Stata Corp., College Station, TX).</td>
</tr>
<tr>
<td>Title: The Diagnosis of Urinary Tract Infection: Comparison of Urine Culture from Suprapubic Aspiration and Midstream Collection in a Children’s Outpatient Department in Nigeria Yr: 1982</td>
<td></td>
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<td>Results/conclusion biases: The use of urine dipstick tests as a method of prescreening specimens by the treating clinician prior to being sent for culture may have introduced bias.</td>
</tr>
<tr>
<td>Publication: Ann Trop Pediatr</td>
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<tr>
<td>Affiliations: Registrar in Pediatrics, Hospital for Sick Children, London United Kingdom, Registrar in Microbiology at Ahmadu Bello University Teaching Hospital, Zaria, northern Nigeria Funding: not reported</td>
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<tr>
<td>Design: observational/nonrandomized comparison study Facility/setting: outpatient clinic in a pediatric children’s teaching hospital Time period: not reported Population/sample: SPA urine was collected from 287 children; 51 of these also had an MSU specimen collected. An additional 124 children had only MSU collected. Comparator: SPA urine Study bias: all SPA collections performed by a single individual</td>
<td>Description: SPA sample collection was by using a 19-gauge needle; the skin was cleaned with iodophor, and a 2nd attempt was made if the 1st aspiration failed. MSU collection was performed under supervision after cleansing of the external genitalia. All specimens were refrigerated prior to being processed for semiquantitative culture. Samples were also processed for urine microscopy. Duration: not reported Training: SPA was performed by a trained physician; mothers were instructed on collection of MSU. Staff/other resources: not reported</td>
<td>Description: 1. No. of bacteria in SPA vs MSU samples were counted. 2. No. of contaminated MSU specimens from patients with sterile SPA specimens were counted. 3. Culture and microscopy results were compared for all specimens Recording method: not reported</td>
<td>Type of findings: observational/comparative Findings/effect size: 1. The initial attempt at SPA was successful in 260/287 patients without complication and was easy to perform. 2. MSU collection was often difficult to perform and took up to 2 h. 3. In 51 patients with paired SPA and MSU specimens, there were no false-positive or false-negative diagnoses made with the MSU samples collected by mothers and from boys with a nonretractable prepuce. Statistical significance/tests: not reported Results/conclusion biases: none reported</td>
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<td>Total quality rating (10-pt. maximum): 6, fair</td>
<td>Total for study (3-pt. maximum): 1 (total for study setting may not be generalizable; SPA collection by single individual)</td>
<td>Total for practice (2-pt. maximum): 2</td>
<td>Total for outcome measures (2-pt. maximum): 1 (recording method not reported)</td>
<td>Total for results/findings (3-pt. maximum): 2 (no statistical analysis)</td>
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<tbody>
<tr>
<td>Authors: Pylkkanen et al. (58)</td>
<td>Design: observational Facility/setting: academic medical center Time period: not reported Population/sample: 477 patients seen at an outpatient clinic were included in the study. Comparator: patients on whom SPA was performed Study bias: outpatients only</td>
<td>Description: Urtine was collected by SPA. 2. CVU was collected from infants with urine collection bags. 3. Midstream CVU was collected from children after cleansing of genitalia with 0.05% chlorhexidine solution. All specimens were examined by microscopy. All specimens were processed on Urinol dipslides. SPA specimens were also plated on blood agar Duration: not reported Training: not reported Staff/other resources: not reported Cost: not reported</td>
<td>Description: Cell counts were classified as ≤10, 11–199, or ≥200/mm³. Bacterial counts were classified as nil, scanty, or numerous by microscopy and as &lt;10⁵, 10⁵–10⁶, or &gt;10⁶ by quantitative culture. Urine collected by SPA was cultured on both Urinol and blood agar plates. A patient was considered infected when both cultures showed growth. Recording method: not reported</td>
<td>Type of findings: observational Findings/effect size: CVU specimens demonstrated significant leukocyte counts, bacterial cell counts, or &gt;10⁶ CFU/ml in culture for 59%, 42%, and 81% of infected (as diagnosed by SPA) symptomatic patients. Diagnostic accuracies of these indices were 88%, 94%, and 99%, respectively. In asymptomatic patients, the accuracies were considerably lower. None of the indices gave sufficient sensitivity or accuracy when used alone. Statistical significance/tests: chi-square test Results/conclusion biases: none reported</td>
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<td>Total quality rating (10-pt. maximum): 7, fair</td>
<td>Total for practice (2-pt. maximum): 2 (may not be generalizable to inpatient patient populations)</td>
<td>Total for outcome measures (2-pt. maximum): 1 (use of Urinol medium may impact quality of culture results)</td>
<td>Total for results/findings (3-pt. maximum): 3</td>
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<td>Authors: Aronson et al. (59)</td>
<td>Design: prospective cross-sectional Facility/setting: teaching hospital Time period: not reported Population/sample: 120 specimens from infants (0–12 mo) and children (3–12 yr) Comparator: SPA urine vs cleanly voided urine Study bias: small sample size</td>
<td>Description: Percutaneous SPA was carried out after the suprapubic area was cleansed with alcohol and iodine. The urine was gently aspirated in a 5- or 10-ml sterile syringe and the needle withdrawn. Cleanly voided urine from infants was collected in a sterile polyethylene urine bag after previous proper cleansing of the vulva, prepuce and perineum. Irrigation of the vulva and prepuce was performed twice with 5 to 10 ml tepid physiologic saline. A clearly voided midstream specimen was obtained from children after a thorough cleansing as described above. Specimens were transported to the laboratory immediately for routine culture. Duration: not reported Training: not reported Staff/other resources: not reported Cost: not reported</td>
<td>Description: Urinary infection was considered to be present if the bacterial count was &gt;10⁵ CFU/ml in SPA urine (true bacteriuria) and was suspected if the bacterial count in cleanly voided urine was &gt;10³ CFU/ml. Shortly after collection, the uncentrifuged urine was also examined for pyuria, expressed as the leukocyte count/mm³. Leukocyte counts of &gt;10 cells/mm³ in SPA urine was considered pathological. Recording method: not reported</td>
<td>Type of findings: observational Findings/effect size: In infants, the suspicion of infection from cleanly voided counts of &gt;10³ CFU/ml could be excluded by a finding of normal SPA urine for 27 babies, 4 babies had infection in their SPA urine despite having only slight or moderate bacteriuria in their cleanly voided urine. 4 patients suspected of having an infection from their cleanly voided urine proved to be free of infection by examination of the SPA urine, whereas 4 patients with true bacteriuria had a low bacterial count in voided urine. Misleading information about bladder urine bacteriuria was thus obtained from bacterial culture of cleanly voided specimens in 39 of 120 examined patients. Statistical significance/tests: not reported Results/conclusion biases: Results may have been influenced by a small sample size.</td>
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<td></td>
<td>Total quality rating (10-pt. maximum): 7, fair</td>
<td>Total for study (3-pt. maximum): 2 (may not be generalizable to inpatient patient populations)</td>
<td>Total for practice (2-pt. maximum): 2</td>
<td>Total for results/findings (3-pt. maximum): 2 (no statistical analysis)</td>
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### TABLE A4 (Continued)

<table>
<thead>
<tr>
<th>Authors: Hardy et al. (56)</th>
<th>Description: SUT, CCU, and SPA specimens were obtained. The perineum and suprapubic regions were cleansed with sterile swabs moistened with distilled water before the specimens were collected. Specimens were sent to the laboratory for semiquantitative culture and microscopy. Duration: not reported Training: not reported Staff/other resources: not reported Cost: not reported</th>
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<tr>
<td><strong>Total quality rating (10-pt. maximum): 8, good</strong></td>
<td><strong>Total for practice (2-pt. maximum): 2 (small sample size)</strong></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Authors: Ramage et al. (51)</th>
<th>Description: 58 paired urine cultures obtained by CCU collection and SPA were taken from 49 infants, 0–24 mo old (22/49 male, 45%). Comparison SPA and CCU collections occurred during a 48-h period. The urine obtained was inoculated onto a dipslide culture plate. The plates were allowed to drain and then replaced securely into the container. The specimen was cultured at 37°C and was interpreted after a minimum of 16 h. Urine cultures were defined as positive in the presence of a pure growth of $&gt;10^5$ CFU/ml in those specimens obtained by CCU collection and as the growth of any quantity of organism in those obtained by SPA. Duration: not reported Training: Parents were given instruction by nurses on collection of CCU specimens. Staff/other resources: not reported Cost: not reported</th>
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<tr>
<td><strong>Total quality rating (10-pt. maximum): 8, good</strong></td>
<td><strong>Total for practice (2-pt. maximum): 2 (small sample size)</strong></td>
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</table>

(Continued on following page)
**TABLE A4 (Continued)**

| Total quality rating (10-pt. maximum): | 8, good |
| Author(s): Cohen et al. (64) | Funding: not reported |
| Title: Disposable Diapers: an Accurate Method for Urine Cultures | |
| Yr: 1997 | |
| Publication: J Fam Pract | |
| Affiliations: Pediatric Ambulatory Center and the Department of Pediatrics, Sacker School of Medicine, Tel Aviv University, Petach Tikvah, and Departments of Neonatology and Pediatrics Infectious Disease Unit, Chaim Sheba, Tel-Hashomer, Israel | |
| |
| Description: all infants had urine collected either by CATH or SPA and by extraction from a disposable diaper. The urine was extracted from the diapers by removing the lining layer of the diaper under aseptic conditions using sterile tweezers, and then pushing the damp fibers into the barrel of a standard 20-ml disposable syringe from which the plunger had been removed. By replacing the plunger and compressing the fibers, urine was easily obtained from the diapers. Ultra-absorbent diapers that contain a gel-like material were excluded from the study because extracting urine from them is difficult and time-consuming. In addition, diapers contaminated with feces or those that had been on the infant for longer than 3 h were excluded. The urine samples were sent to the laboratory and were cultured using standard bacteriologic techniques. |
| Duration: not reported |
| Training: not reported |
| Staff/other resources: not reported |
| Cost: not reported |
| Results/findings: Type of findings: comparative findings. Effect size: Urinary tract infection was demonstrated by SPA or CATH specimen collection from 5 (11.2%) infants (4 female and 1 male). For all 5 children, urine cultures showed more than 10^6 CFU/ml of the same single organism from urine that had been collected from both the diapers and the SPA or CATH specimens (sensitivity of 100% [95% CI] and specificity of 94% [93/ 333]). A statistical analysis revealed a wide CI and estimated the low end to be 55% for sensitivity and 82% for specificity. These results were derived using the binomial distribution. |
| Statistical significance/test: A statistical analysis (method not reported) revealed a wide CI and estimated the low end to be 55% for sensitivity and 82% for specificity. These results were derived using the binomial distribution. |
| Results/conclusion biases: The small sample size, particularly for infants with positive results, explains why the confidence limits are much lower than the estimated values. |

| Total quality rating (10-pt. maximum): | 5, fair |
| Author(s): Grisaru-Soen et al. (52) | Funding: not reported |
| Title: False-Positive Urine Cultures Using Bag Collection | |
| Yr: 2000 | |
| Publication: Clin Pediatr Infectious Disease, Pediatrics, Pediatric Nephrology, Microbiology, Chaim Sheba Medical Center, and Sacker Faculty of Medicine, Tel Aviv University, Israel | |
| |
| Description: SPA was done first, followed by bagged urine collection. Specifics and instructions were not reported for how procedures were performed; urine transport was not described, and urine workup was not described or defined. |
| Duration: not reported |
| Training: not reported |
| Staff/other resources: not reported |
| Cost: not reported |
| Results/findings: Type of findings: comparison findings. Effect size: 7 SPA specimens exhibited pure growth of organisms, for a true UTI rate of 14%, 14 bagged urine specimens exhibited pure growth (13 of which were falsely positive, as SPA was negative). 23 exhibited mixed growth, and 1 that exhibited mixed growth also had a positive SPA result; the remaining mixed-growth specimens were negative by SPA. The bagged-urine contamination rate was 62%. 30/35 bagged urine samples gave a false-positive result as either pure or mixed growth. Negative bagged urine samples were suitable to exclude a diagnosis of UTI. |
| Statistical significance/test: not reported |
| Results/conclusion biases: none noted | |

(Continued on following page)
TABLE A4 (Continued)

| Authors: Etoubleau et al. | Design: prospective cross-sectional Facility/setting: academic medical center/emergency departments Time period: October 2004–June 2007 Population/sample: 192 non-toilet-trained children of <3 yr of age from 2 emergency departments (all had fever of unknown origin on presentation) Comparator: urine obtained by CATH Study bias: The indication for CATH was left up to the physician, depending on bag urinalysis results and the patient’s clinical and biological data. | Description: An adhesive urine bag was placed on the child by a nurse. Urinalysis was performed, and then depending on this information, CATH was performed. Urine culture results from bag vs catheter-obtained specimens were assessed, with catheter culture as the reference. Duration: 44 mo Training: nurses trained on catheterization procedure Staff/other resources: not reported Cost: not reported | Description: comparison of bag cultures and catheter cultures for making a clinical diagnosis of UTI. Definitions were as follows: positive urine culture for bag specimens, ≥10^5 CFU/ml; positive urine culture for CATH specimens, ≥10^5 CFU/ml (1 species only); polybacterial urine culture (considered a contaminated sample), ≥10^5 or ≥10^4 CFU/ml (depending on collection method) and >2 species present upon culture; negative urine culture, all the other specimens. Recording method: not reported | Type of findings: comparison findings/efficacy size: A total of 7.5% and 29% of bag-obtained specimens had false-positive and false-negative results, respectively, compared to CATH specimens. Bag-obtained specimens led to either a misdiagnosis or an impossible diagnosis in 40% of cases vs 5.7% when urethral catheterization was used. Statistical significance/test: percentage comparisons performed using the chi-square test Results/conclusion biases: Failure to perform a successful catheterization was common. The contamination rate for CATH specimens was also higher than expected. |


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Jacob Franek earned his master’s degree in health sciences with a focus in community health and epidemiology from the University of Toronto in 2007. Over the last 10 years, he has held positions as senior clinical epidemiologist specializing in health technology assessment/systematic review and evidence-based methods with Cancer Care Ontario and the Medical Advisory Secretariat (now Health Quality Ontario) of the Ontario Ministry of Health and Long-Term Care and is currently serving as an internal senior consultant for Kaiser Permanente and as an external consultant in health technology assessment/systematic review, evidence grading, evidence-based decision-making, and biostatistical analysis for various organizations, including the Centers for Disease Control and Prevention and the American Society for Microbiology. Given the general lack of evidence-based guidelines across microbiology and laboratory medicine, he is interested in advancing evidence-based knowledge in these fields.


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