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A Point Prevalence Study of Health Care Associated Urinary Tract Infections in Six Australian Hospitals

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Abstract

Background: Healthcare Associated Infections (HAIs) are the most common complication of hospitalisation with urinary tract infections accounting for over 30%. About 80% of healthcare associated urinary tract infections (HAUTIs) have been traced to use of indwelling urinary catheters (catheter associated urinary tract infections, CAUTIs). Prevalence surveys are a relatively simple strategy providing baseline HAIs information. We conducted HAUTI and CAUTI point prevalence in 6 Australian hospitals to inform a national point prevalence process and compare two internationally accepted HAUTI definitions. We also assessed completeness and efficacy of catheter care documentation practices, sensitivity of clinical record documentation, microbiology laboratory and coding data at identifying HAUTIs and CAUTIs.

Methods: Data were collected from three public and three private hospitals. Demographic and clinical data were obtained from patients' notes and laboratory records. Approximately two months later DRG and ICD-10 coding data were retrieved by medical records departments.

Results: A total of 1109 patients were surveyed. Overall HAUTI and CAUTI prevalence was 1.4% (15/1109) and 0.9% (10) respectively. *Staphylococcus aureus* and *Escherichia coli* were the most common pathogens. One quarter (26.3%) of patients had a urinary catheter and fewer than half had appropriate documentation. Eight of the 15 patients ascertained to have a HAUTI based on clinical records (six being CAUTI) were also coded by the medical records department with an ICD-10 code for UTI diagnosis. The Health protection Agency Surveillance definition had a positive predictive value of 91.67% (confidence interval 64.61-98.51) compared against the Centers for Disease Control and Prevention definition.

Conclusions: These study results provide a foundation for a national Australian point prevalence study and inform the development and implementation of targeted HAI surveillance more broadly.

Strengths and limitations of this study

- This is the first study to compare two internationally accepted definitions in categorising patients with CAUTIs, namely the Health Protection Agency and Centers for Disease Control and Prevention definitions.
- This study demonstrates the feasibility of conducting point prevalence surveys of HAUTIs in a standardised manner to facilitate comparisons over time within individual health facilities.
- A limitation of this study is that the survey was conducted in only six hospitals within two states and territories limiting the generalisability of the results. However, there were significant findings enabling recommendations for a future national point prevalence study to be made.

Background/Rationale

Healthcare associated infections (HAIs) have considerable medical consequences and pose a significant problem for patient safety.[1] A recent systematic review and meta-analysis of 220 international articles indicated that the prevalence and incidence of HAIs is 10% and 7% per 100 patients, respectively.[2] Further, the prevalence of infected patients is 11% per 100 patients.[2] Fifty percent of the reviewed prevalence studies stated magnitudes of infected patients higher than 10% per 100 patients.[2] The Centers for Disease Control and Prevention (CDC) estimates that 1.7 million people develop HAIs and 100,000 people die of HAI related complications each year in the United States.[3] The first European Union (EU)-wide point prevalence survey (PPS) of healthcare-associated infections and antimicrobial use in hospitals conducted in 2011–2012, estimated that on any given day, about 80 000 patients have at least one HAI, i.e. one in 18 patients in a European hospital has an HAI.[4] The studies support the view that HAIs are the most common complication of hospitalisation. This concept is not new, as demonstrated in a landmark paper "*To Err is Human: Building a Safer Health System*" published in 1999 by the Institute of Medicine (IOM).[5] However, these infections are a potentially preventable adverse event rather than an unpredictable complication and it is possible to significantly reduce the rate of HAIs through effective infection prevention and control.[6]

HAIs could be prevented by sustained, multifaceted infection prevention and control programmes, including the Hawthorne effect of surveillance.[4] Although prospective active surveillance is considered to be the gold standard for surveillance, prevalence surveys are quite useful as they can provide baseline information about the occurrence and distribution of HAI, are generally easy to conduct, relatively inexpensive and not too time-consuming.[7-8] National surveillance of HAI has been introduced in North America and in many European countries and national prevalence surveys of HAI are also increasingly common.[8]

The urinary tract accounts for more than 30% of infections reported by acute care hospitals.[9] Virtually all healthcare-associated urinary tract infections (HAUTIs) are caused by instrumentation of the urinary tract with about 80% traced to the use of indwelling urinary catheter.[10] This is not surprising because the use of urethral catheters is very common with 15% to 25% of hospitalised patients receiving a short-term indwelling urinary catheter.[11-14] Calculation of how many CAUTIs may be preventable varies considerably with estimates from unpublished data ranging from 17% to 69%.[15] Given recommended infection control

measures, up to 380,000 infections and 9000 deaths related to CAUTIs per year could be prevented in the United States.[15]

Unlike other countries, Australia has not recently conducted a national point prevalence study on HAIs. The last Australian national prevalence survey for nosocomial and community-acquired infections was conducted in 1984,[16] with authors reporting a prevalence of 6.3% for HAIs with the urinary tract contributing to 22% of infections.[16] The most recent study to report the incidence of UTIs in Australia was conducted in two hospitals, with authors reporting an incidence of 1.66%.[17]

To date, in Australia there is no specific national strategy and surveillance system in place to address HAUTIs and CAUTIs.[18-19] Several Australian States undertake surveillance activities for healthcare associated infections including the Victorian Hospital Acquired Surveillance Programme (VICNISS)); South Australian Infection Control Service (SANIT); the Centre for Healthcare Related Infection Surveillance and Prevention (CHRISP) in Queensland;[18, 20] the Tasmanian Infection Prevention and Control Unit (TIPCU) and the Hospital Infection Surveillance program in Western Australia (HISWA). These surveillance programmes differ considerably, with variability in infections surveyed and level of participation by hospitals with no mandatory participation required for hospitals within these states except New South Wales.[21] At present, there is no national or State level surveillance for HAUTIs in Australia hospitals.

To provide the foundation for a national point prevalence study and for a future prospective interventional study, we conducted a preliminary study in 6 Australian hospitals. The aims and objectives of this study were to (1) establish the point prevalence of healthcare associated urinary tract infections (HAUTI) and catheter associated urinary tract infections (CAUTI), (2) assess completeness and efficacy of documentation practices related to care of urinary catheters, (3) compare two internationally accepted definitions in categorising patients with CAUTIs, namely the Health Protection Agency[22] and Centers for Disease Control and Prevention[9] definitions and (4) compare the sensitivity of microbiology laboratory data, coding data and clinical record documentation at identifying cases of HAUTIs and CAUTIs. It is expected that the findings from this study will provide policy makers and healthcare providers in Australia with HAI data to inform the development and implementation of targeted surveillance and high-impact HAI prevention programs, as well as testing a process for point prevalence of HAUTI.

Methods

Study Design. Cross sectional study

Ethics Approval. Approval for the study was obtained from four health service human research ethics committees and one university committee.

Setting and Data Sources/Measurement. Three publicly funded and three private hospitals in two Australian jurisdictions participated in the point prevalence survey. Two of the three publicly funded hospitals had greater than 400 beds each and similar case mix which included ICU, 24 hour emergency department, Haematology/Oncology units, dialysis units, Paediatrics/Women and Children, Elective and Emergency surgery. The third public hospital had fewer than 400 beds and no paediatric or dialysis services. One private hospital was a rehabilitation hospital and the other two provided acute medical and surgical services.

The survey was conducted over the first six months of 2013 in two phases. The first phase involved two public and two private hospitals and the data were collected concurrently over a single day at these sites. The second phase of the study was conducted in the remaining private and public hospital after additional funding had been obtained. Similar to Phase 1, patient records were concurrently surveyed at both sites.

For each hospital, the survey was conducted using a standardised paper-based questionnaire developed by the researchers from the CAUTI toolkit resources of the Centres for Disease Control and Prevention.[23] On the day of the point prevalence study, demographic and clinical data were obtained from patients' notes and laboratory records. Data collected included age, sex, ward speciality, presence of urinary catheter and documentation of insertion, and causative organism where appropriate of all eligible patients. For each patient who had a catheter inserted, documentation was reviewed to determine whether the need for the catheter was assessed daily, consistent with best practice recommendations.[24-25] A separate protocol paper provides more details of the study methods.[26]

The DRG and ICD10 coding data were retrieved by the medical records departments approximately two months after completion of the point prevalence survey. Data from the standardised paper based questionnaires were subsequently entered into a purpose designed Excel ™ database and exported into a statistical software package for analysis.

Participants. Records of patients of all ages, hospitalised on the day of the point prevalence at the study sites, were eligible for inclusion, with some exceptions. Outpatients,

patients in adult mental health units, patients categorised as maintenance care type (i.e. patients waiting to be transferred to a long term care facility) and those in the emergency department during the duration of the survey were excluded.

Bias. Inter-rater reliability was enhanced by development and use of a standardised training program, with mastery being formally assessed prior to data collection, to reduce the possibility of information bias.[26] The data were collected by trained research assistants who were all registered or enrolled nurses. Before the survey dates, all research assistants were provided with a training package and underwent a 2 hours of mandatory face-to-face training and assessment to assist them in collecting point prevalence data and to enhance inter-rater reliability in the application of HAUTI and CAUTI definitions and other survey procedures. The training package and program were developed using the Health Protection Scotland Education and Training Events resources.[27]

Study Size. All hospitalised persons in the participating organisation who met eligibility criteria on a given day were included in the study.

Variables. The main outcome measure was HAUTIs with CAUTI being specifically identified within this outcome. Healthcare associated infection status was defined as hospitalisation greater than 48 hours. Healthcare associated urinary tract infections and CAUTIs were ascertained by using two sets of criteria, those established by the Health Protection Agency / European Centre for Disease Prevention[22] and Control and by the Centers for Disease Control and Prevention.[9] These definitions are complex therefore flow diagrams were provided to research assistants' to assist them with case definitions.[26]

All patients were ascribed one or more diagnosis related codes on discharge from hospital. These codes are known as the Australian Refined Diagnosis Related Groups (AR-DRGs). This classification system enables a hospital's case mix to be described in a clinically meaningful way, enables subsequent use to identify resources required by the hospital, and forms the basis for funding in some Australian States and Territories.[28] Our study collected ICD-10 codes for infection and ICD-10 CM for procedures[29] to identify those relevant to urinary tract infections and catheterisation.

Statistical Methods. Data analysis was performed using IBM Statistics SPSS version 20. Descriptive analysis such as counts and percentages for categorical data and measures of central tendency and dispersion for continuous data was performed. The HAUTI and CAUTI point prevalence were calculated using the total patient population surveyed as the

denominator. The sensitivity and positive predictive values of Centers for Disease Control and Prevention (CDC) and Health Protection Agency (HPA) surveillance definitions for HAUTI and CAUTI were compared. Cross tabulation and measures of association were applied using Chi-square tests and Fishers Exact test where appropriate to explore differences between public and private hospitals and factors significantly associated with HAUTI and CAUTI.

Results

A total of six hospitals were surveyed over a six month period and all data have been aggregated. Sub-group analysis is limited to public and private hospital status to prevent potential identification of individual participating institutions.

Participants. A total of 1109 patients were surveyed on the designated days. Of these, 505 (45.5%) were male and 604 (54.5%) were female. The median age was 64 years (interquartile range, 42-79 years). Table 1 shows the results stratified by hospital type with 905 patients surveyed from the three public hospitals and 204 from the three private hospitals. The case mix of patients based on the DRG data varied across public and private hospitals with the majority of patients managed for diseases of the musculoskeletal system and connective tissue. This was followed by diseases of the digestive system for the private hospitals and patients assigned codes based on factors influencing health status and other contacts with health services for the public hospitals (Table 1).

INSERT TABLE 1

Prevalence of UTI. The overall prevalence of HAUTI was 1.4% (15/1109) and the prevalence of CAUTIs was 0.9 % (10). *Staphylococcus aureus* and *Escherichia coli* were the most common pathogens. Table 2 presents the microbial characteristics of all infections. Of the 1109 patients who were included in the survey, 1.1% met the CDC surveillance criteria for symptomatic UTI and 0.2% met the CDC criteria for asymptomatic UTI. 1.0% of the patients met the microbiological HPA criteria and 0.2% the non-microbiological HPA criteria. There was one patient who had both Microbiological and Non-Microbiological HPA confirmation of UTI.

Tables 3 and 4 provide the comparison of surveillance definitions, the positive predictive value and sensitivity with the HPA definition classified as the “test” and the CDC definition as the “gold standard”**.**

INSERT TABLES 2, 3 & 4

Pattern of Catheter Usage. One quarter (26.3%) of all surveyed patients had a urinary catheter in place during the audit admission with the majority being indwelling catheters (88.7%). Less than half of patients surveyed had appropriate documentation, such as designation of person inserting catheter (28.8%) and reason for insertion (38.7%) (Table 5). The majority of catheters were inserted for peri-operative use for selective surgical procedures (38.9%), acute urinary retention (24.8%), and urinary output monitoring in critically ill patients (22.1%).

Of the 292 who had a catheter in during the audit admission only 7 (2.4%) patients were assigned ICD-10 codes by the medical records department as having a urinary catheter with two (0.7%) coded as having a "bladder catheter" during their admission.

INSERT TABLE 5

ICD-10 Codes. Eighty-six (7.8%) patients were coded by the medical records department as having a UTI. This coding did not take into account whether they were healthcare associated or not. Australian coding data does not distinguish between HAI cases and non-HAI cases. This is unlike the US coding data which provides a present on admission (POA) indicator code to inpatients helping to identify hospital acquired infections.[30] Eight of the 15 patients who were ascertained to have a HAUTI based on the CDC and HPA criteria (with six of these being CAUTI) were also coded by the medical records department with an ICD-10 code for UTI diagnosis.

Discussion

There were four main findings from this study: the point prevalence of HAUTI was comparable to other studies; identification of poor standards of documentation; a suggestion that the CDC surveillance definition has a higher positive predictive value compared to the HPA; and that clinical coding data grossly underestimates the incidence of HAUTI. Each of these findings will now be explored in more detail.

The 1.4% HAUTI point prevalence and CAUTI point prevalence for this study are consistent with previously published reported rates, both nationally[17] and internationally.[31] Whilst this prevalence may seem low, approximately 20-30% of all HAIs are UTIs.[31-32] Extrapolating our data, we estimate that on any given day, there are approximately 1120

Australian inpatients with a HAUTI, assuming 80 000 acute hospital beds in Australia.[33] In addition, a proportion of bacteraemias are associated with UTIs and these have an associated mortality.[34-36] In the era of increasing antimicrobial resistance, particularly in Gram negative organisms, patient outcomes have the potential to worsen demonstrating a growing need for vigilance in infection prevention and HAUTI surveillance.

In this study, documentation relating to catheter insertion and management in all healthcare facilities in the study was poor. There are two main implications that follow from this – evidence based practice and health economics. For evidence based practice, the lack of documentation about who inserted catheter, catheter type and reasons for insertion, would not inspire confidence in patients about the quality of care provided or compliance with evidence based practice. For example, our survey evaluated documentation against national and international practice recommendations such as whether the ongoing need for a catheter is regularly reviewed.[24-25, 37] The biggest risk for infection is duration of catheter.[37] While it is reasonable to assume that the need for the catheter was regularly renewed for some patients and simply not documented, it is also probable that review of the need for catheter was not undertaken for many. Minimising the number of patients with catheters and the duration of catheterisation could significantly reduce the incidence of UTIs and HAIs more generally.[24] We have identified a potential gap in best practice which lends itself to future prospective interventional studies targeting improvements in urinary catheter care. We identified a further issue with poor documentation as less than 10% of urinary catheter usage was identified by ICD 10 coding. This has potential implications for funding, depending on the funding model applied.

In this study, the CDC surveillance definition identified more patients with HAUTI than the HPA definition. The difference in positive predictive value, however, was not statistically significant. Research assistants responsible for data collection overwhelmingly reported that the HPA definition was easier to use. Therefore, whilst the CDC definition is recognised as the gold standard,[38] and HPA in our study had a lower capture rate, use of the HPA definition is still likely to predict 91.7% (Confidence Interval: 64.6-98.5) of infections diagnosed through use of the CDC definition. Therefore given the much greater ease of use of the HPA definition, we recommend the use of the HPA definition in future point prevalence studies. Any potential issue of underestimating the incidence of HAUTI using the HPA surveillance definition is less important where data are used in a quality improvement

framework, as these data can be used to inform and evaluate interventions[39] rather than for diagnostic purposes or for performance management (i.e., trends overtime being most important). Other authors have commented that prospective UTI surveillance is costly and time consuming to conduct[40-41] therefore we explored alternatives to prospective UTI surveillance by comparing our prevalence data with post discharge coding data. In our study ICD coding missed 50% of HAUTIs. If ICD 10 coding are used to determine the incidence of HAUTI, for reporting purposes our study suggests that such a method will grossly underestimate the number of infections, with implications for funding arrangements. This finding has also been found for other infections.[42]

Recommendations for Practice, Policy and Research

To enable the reduction of HAIs related to the genitourinary tract it is important that all health care facilities have appropriate policies and protocols for insertion of either a urethral or supra pubic catheter. It is important that these policies and protocols are evidenced based. However, prior to inserting a catheter the question of whether the patient requires this procedure should be raised. If the decision is made to insert a catheter then consideration should be given to the size of catheter to insert, the reason for the insertion and duration of time that the catheter will be in place to allow timely removal of the catheter. It is important to consider the length of time it is anticipated that the catheter will be required as this will help with the selection of catheter type. When developing protocols information that should be included are: the day to day management of such a device, including catheter care and securing of the device and management of drainage. While management of drainage was not included in our study, it is also important to consider this. All information relating to the catheter and its care should also be documented in the notes (this could be in the form of a sticker to be easily found in the notes) and on the care plan.

Documentation by medical and nursing staff is important for the day to day infection prevention and control and to alert staff to ensure timely removal of urinary catheters. If a CAUTI is diagnosed then documentation should include: causative organism, what antibiotics have been commenced, and whether the antibiotics are appropriate to treat that microorganism. Other relevant notes are actions taken, such as removal or replacement of the catheter.

To improve health outcomes for patients it is important to continue exploration of ways to identify and reduce HAUTIs and CAUTIs. We have shown it is feasible to conduct

prevalence across 6 health institutions and funding should be sought for a national point prevalence of UTIs as demonstrated by countries already undertaking this.[4] Analysing national point prevalence data will provide a baseline for intervention studies that test care bundles to reduce HAUTIs and their sequelae.[43]

Currently, it appears that ICD10 coding is not a reliable way of monitoring prevalence of HAUTI, at least in some healthcare facilities. Our findings were consistent with other HAI coding.[42] This potential under-reporting of infections has implications for policy and healthcare reimbursement, although in some US jurisdictions, healthcare facilities are penalised for HAIs rather than being reimbursed.[44-45] We recommend that facilities undertake audits to compare clinical and coding data periodically.

There are some limitations in our study. The survey was conducted in only six hospitals within two states and territories limiting the generalisability of the results. However, there were significant findings enabling recommendations for a future national point prevalence study to be made. Another limitation of our study is the reliance on clinical records and not direct diagnosis. This was overcome by using research assistants with some prior clinical and infection control knowledge, for example registered nurses, for data collection. The research assistants were adequately trained and the outcome of the training was evaluated by post training case study assessments.[26] Such a process also enhanced inter-rater reliability. There were no previous HAUTI and CAUTI rates for comparison within the study sites as they had not collected this type of data before. As earlier stated, the findings can now be used to make recommendations for conducting point prevalence surveys in a standardised manner to facilitate comparisons over time within individual health facilities. Despite the study limitations, this survey has identified some priority areas including efficacy of documentation practices related to care of urinary catheters which are key to preventing CAUTIs. There were also no obvious sources of bias.

Conclusion

To tackle the issue of CAUTIs and other HAIs in Australia, it is imperative to develop a national surveillance system based on validated methods and definitions which have been found to be effective in other developed countries. This study provides a foundation for the development of a national infection control initiative in our rapidly evolving healthcare environment and associated challenges with drug resistance.

Author contribution

All authors contributed to design of study and development of instruments. BM, WB and OF supervised data collection. OF & AG conducted initial data analysis. All authors contributed to further data analysis and manuscript preparation.

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Competing Interests

None.

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Data sharing statement

No additional data available.

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Tables

Table 1. Patient Demographics

Characteristic			Private Hospitals *n*(%) *n* = 204	Public Hospitals *n*(%) *n* = 905	Total (%) *N* = 1109
Age Category (in years)		<35	21 (10.3)	210 (23.2)	231 (20.8)
		35-64	46 (22.5)	292 (32.3)	338 (30.5)
		65-84	82 (40.2)	299 (33.0)	381 (34.4)
		≥85	55 (27.0)	104 (11.5)	159 (14.3)
Gender		Male	79 (38.7)	426 (47.1)	505 (45.5)
		Female	125 (61.3)	479 (52.9)	604 (54.5)
Ward Specialty	Surgery		69 (33.8)	300 (33.1)	369 (33.3)
	General Medicine		55 (27.0)	273 (30.2)	328 (29.6)
	General Practice/Rehabilitation/Geriatric Medicine		37 (18.1)	100 (11.0)	137 (12.4)
	Obstetrics/Gynaecology		17 (8.3)	86 (9.5)	103 (9.3)
	Oncology		17 (8.3)	55 (6.1)	72 (6.5)
	Paediatrics		7 (3.4)	63 (7.0)	70 (6.3)
	High Dependency Unit		0 (0)	28 (3.1)	28 (2.5)
	Other (Pain management)		2 (1.0)	0 (0)	2 (0.2)
DRG*	Diseases of the musculoskeletal system and connective tissue		41 (20.1)	130 (14.4)	171 (15.4)
	Factors influencing health status and other contacts with health services		5 (2.5)	89 (9.8)	94 (8.5)
	Diseases of the digestive system		18 (8.8)	63 (7.0)	81 (7.3)
	Diseases of the circulatory system		8 (3.9)	65 (7.2)	73 (6.6)
	Diseases of the respiratory system		14 (6.9)	47 (5.2)	61 (5.5)
	Pregnancy, childbirth and pueperium		11 (5.4)	47 (5.2)	58 (5.2)
	Diseases of the nervous system		15 (7.4)	39 (4.3)	54 (4.9)
	Newborns and other neonates		16 (7.8)	27 (3.0)	43 (3.9)
	Major procedures where the principal diagnosis may be associated with any Major		16 (7.8)	18 (2.0)	34 (3.1)

	Diagnostic Category			
	Diseases of the kidney and urinary tract	8 (3.9)	25 (2.8)	33 (3.0)
	Other¥	38 (18.6)	133 (14.7)	171 (15.4)
	Missing□	14 (6.9)	222 (24.5)	236 (21.3)

*DRG = Diagnosis Related Group

¥ = Diseases of the skin, subcutaneous tissue and breast; Injuries, poisoning and toxic effects of drugs; Diseases of the hepatobiliary system and pancreas; Neoplastic Diseases (haematological and solid neoplasms); Infectious and parasitic diseases; Endocrine, nutritional and metabolic diseases and disorders; Diseases of the ear, nose, mouth, and throat; Diseases of the female reproductive system; Diseases of the male reproductive system; Mental diseases and disorders; Diseases of the blood and blood forming organs and immunological diseases; Diseases of the eye; Burns

□ = Missing DRG data includes all patients in one public hospital

Table 2. Microbial Characteristics for non-CAUTI HAUTIs and CAUTIs

Type of Organism		Non-CAUTI *N* = 5	ICD10 code YES/NO	CAUTI *N* = 10	ICD code YES/NO	TOTAL *N* = 15
GM +ve	*Enterococcus* species	1	no	1	no	2
	Staphylococcus aureus	1	yes	2	1 yes 1 no	3
GM -ve	Escherichia coli	0	NA	2	yes	2
	Klebsiella species	0	NA	1	no	1
	Proteus species	2	no	0	NA	2
	Pseudomonas species	1	no	0	NA	1
Fungi	*Candida* species	0	NA	3	1 yes 2 no	3
Organism not Listed		0	NA	1	yes	1

NA = Not Applicable

Table 3. Comparison of CDC and HPA Surveillance definitions

	CDC* POSITIVE	CDC NEGATIVE	TOTAL
HPA POSITIVE	11 (1.0%)	1 (0.1%)	12 (1.1%)
HPA NEGATIVE	3 (0.3%)	1094 (98.6)	1097 (98.9%)
TOTAL	14 (1.3%)	1095 (98.7%)	1109 (100.0%)

*NB: For the purposes of calculation, the CDC definition was considered to be gold standard

Table 4. Estimates of the Positive Predictive Value, Sensitivity and Confidence Intervals of the HPA surveillance definition

Result	Value (%)	Confidence Interval
Sensitivity	78.57	(52.41, 92.43)
Specificity	99.91	(99.48, 99.98)
Positive Predictive Value	91.67	(64.61, 98.51)
Negative Predictive Value	99.73	(99.2, 99.91)
Diagnostic Accuracy	99.64	(99.08, 99.86)

Table 5. Catheter Information

Characteristic		Private Hospitals (%) *n* = 60	Public Hospitals (%) *n* = 232	Total (%) *N* = 292
Catheter at any time During this Admission	Yes	60 (29.4)	232 (25.6)	292 (26.3)
	No	144 (70.6)	673 (74.4)	817 (73.7)
Presence of Catheter	Currently insitu	29 (48.3)	146 (62.9)*	175 (59.9)
	Catheter inserted but removed during admission	31 (51.7)	85 (36.7)	116 (39.7)
	Intermittent	0 (0)	1 (0.4)	1 (0.4)
Catheter Location	Indwelling	54 (90.0)	205 (88.4)	259 (88.7)
	Suprapubic	4 (6.6)	10 (4.3)	14 (4.8)
	Intermittent	0 (0)	2 (0.9)	2 (0.7)
	Both indwelling and suprapubic	1 (1.7)	0 (0)	1 (0.3)
	Not documented	1 (1.7)	15 (6.4)	16 (5.5)
Catheter Type	Silver alloy	0 (0)	1 (0.4)	1 (0.3)
	Silicone	7 (11.7)	55 (23.7)	62 (21.2)
	Antimicrobial	0 (0)	0 (0)	0 (0)
	Foley	0 (0)	19 (8.2)	19 (6.5)
	Latex	0 (0)	2 (0.9)	2 (0.7)
	Other	0 (0)	11 (7.8)	11 (3.8)
	Not documented	53 (88.3)	144 (62.1)	197 (67.5)
Catheter Size (French Grade)	6	0 (0)	1 (0.4)	1 (0.3)
	10	0 (0)	1 (0.4)	1 (0.3)
	12	16 (26.7)	16 (6.9)	32 (11.0)
	14	10 (16.7)	54 (23.3)	64 (22.0)
	16	8 (13.3)	19 (8.2)	27 (9.2)
	18	0 (0)	3 (1.3)	3 (1.0)
	20	2 (3.3)	2 (0.9)	4 (1.4)
	22	0 (0)	1 (0.4)	1 (0.3)
	24	1 (1.7)	0 (0)	1 (0.3)

	Not documented	24 (40.0)	135 (58.2)	159 (54.5)
Inserted by	Nurse	5 (8.3)	46 (19.8)	51 (17.5)
	Doctor	13 (21.7)	18 (7.8)	31 (10.6)
	Other (student)	1 (1.7)	1 (0.4)	2 (0.7)
	Not documented	41 (68.3)	167 (72.0)	208 (71.2)
Reason for Insertion Stated	Yes	36 (60.0)	77 (33.2)	113 (38.7)
	No	24 (40.0)	155 (66.8)	179 (61.3)
Cleaning Solution	Chlorhexidine	0 (0)	1 (0.4)	1 (0.3)
	Unknown	60 (100)	231 (99.6)	291 (99.7)
Ongoing Need for Catheter Reviewed (days)	0	34 (56.7)	157 (67.7)	191 (65.4)
	1	10 (16.7)	35 (15.1)	45 (15.4)
	2-3	5 (8.3)	24 (10.3)	29 (9.9)
	4-5	1 (1.7)	3 (1.3)	4 (1.4)
	>5	0 (0)	3 (1.3)	3 (1.0)
	Not documented	10 (16.7)	10 (4.3)	20 (6.8)

*It is unknown if catheter still insitu for 3 of these participants at time of survey.

1 patient had both indwelling and suprapubic catheters of 2 different sizes.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract✓
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found✓
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported✓
Objectives	3	State specific objectives, including any prespecified hypotheses✓
Methods		
Study design	4	Present key elements of study design early in the paper✓
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection✓
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants✓
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable✓
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group✓
Bias	9	Describe any efforts to address potential sources of bias✓
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why✓
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding✓
		(*b*) Describe any methods used to examine subgroups and interactions✓
		(*c*) Explain how missing data were addressed✓
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy Not Applicable
		(*e*) Describe any sensitivity analyses✓

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders✓
		(b) Indicate number of participants with missing data for each variable of interest✓
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures✓
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized✓
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period Not Applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses✓
Discussion		
Key results	18	Summarise key results with reference to study objectives✓
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias✓
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence✓
Generalisability	21	Discuss the generalisability (external validity) of the study results✓
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based✓

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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A Point Prevalence Cross Sectional Study of Health Care Associated Urinary Tract Infections in Six Australian Hospitals

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A Point Prevalence Cross Sectional Study of Health Care Associated Urinary Tract Infections in Six Australian Hospitals

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Abstract

Objectives: Urinary tract infections account for over 30% of healthcare associated infections. The aim of this study was to determine healthcare associated urinary tract infection (HAUTI) and catheter associated urinary tract infection (CAUTI) point prevalence in six Australian hospitals to inform a national point prevalence process and compare two internationally accepted HAUTI definitions. We also described the level and comprehensiveness of clinical record documentation, microbiology laboratory and coding data at identifying HAUTIs and CAUTIs.

Setting: Data were collected from three public and three private Australian hospitals over the first six months of 2013.

Participants: A total of 1109 patients were surveyed. Records of patients of all ages, hospitalised on the day of the point prevalence at the study sites were eligible for inclusion. Outpatients, patients in adult mental health units, patients categorised as maintenance care type (i.e. patients waiting to be transferred to a long term care facility) and those in the emergency department during the duration of the survey were excluded.

Outcome measures: The primary outcome measures were the HAUTI and CAUTI point prevalence.

Results: Overall HAUTI and CAUTI prevalence was 1.4% (15/1109) and 0.9% (10/1109) respectively. *Staphylococcus aureus* and *Candida species* were the most common pathogens. One quarter (26.3%) of patients had a urinary catheter and fewer than half had appropriate documentation. Eight of the 15 patients ascertained to have a HAUTI based on clinical records (six being CAUTI) were coded by the medical records department with an ICD-10 code for UTI diagnosis. The Health protection Agency Surveillance definition had a positive predictive value of 91.67% (confidence interval 64.61-98.51) compared against the Centers for Disease Control and Prevention definition.

Conclusions: These study results provide a foundation for a national Australian point prevalence study and inform the development and implementation of targeted HAI surveillance more broadly.

Strengths and limitations of this study

- This is the first study to compare two internationally accepted definitions in categorising patients with CAUTIs, namely the Health Protection Agency and Centers for Disease Control and Prevention definitions.
- This study demonstrates the feasibility of conducting point prevalence surveys of HAUTIs in a standardised manner to facilitate comparisons over time within individual health facilities.
- A limitation of this study is that the survey was conducted in only six hospitals within two states and territories limiting the generalisability of the results. However, there were significant findings enabling recommendations for a future national point prevalence study to be made.

Background/Rationale

Healthcare associated infections (HAIs) have considerable medical consequences and pose a significant problem for patient safety.[1] A recent systematic review and meta-analysis of 220 international articles indicated that the prevalence and incidence of HAIs is 10% and 7% per 100 patients, respectively.[2] Further, the prevalence of infected patients is 11% per 100 patients.[2] Fifty percent of the reviewed prevalence studies stated magnitudes of infected patients higher than 10% per 100 patients.[2] The Centers for Disease Control and Prevention (CDC) estimates that 1.7 million people develop HAIs and 100,000 people die of HAI related complications each year in the United States.[3] The first European Union (EU)-wide point prevalence survey (PPS) of healthcare-associated infections and antimicrobial use in hospitals conducted in 2011–2012, estimated that on any given day, about 80 000 patients have at least one HAI, i.e. one in 18 patients in a European hospital has an HAI.[4] The studies support the view that HAIs are the most common complication of hospitalisation. This concept is not new, as demonstrated in a landmark paper "*To Err is Human: Building a Safer Health System*" published in 1999 by the Institute of Medicine (IOM).[5] However, these infections are a potentially preventable adverse event rather than an unpredictable complication and it is possible to significantly reduce the rate of HAIs through effective infection prevention and control.[6]

HAIs could be prevented by sustained, multifaceted infection prevention and control programmes, including the Hawthorne effect of surveillance.[4] Although prospective active surveillance is considered to be the gold standard for surveillance, prevalence surveys are quite useful as they can provide baseline information about the occurrence and distribution of HAI, are generally easy to conduct, relatively inexpensive and not too time-consuming.[7-8] National surveillance of HAI has been introduced in North America and in many European countries and national prevalence surveys of HAI are also increasingly common.[8]

Urinary tract infections account for more than 30% of HAIs reported by acute care hospitals.[9] Virtually all healthcare-associated urinary tract infections (HAUTIs) are caused by instrumentation of the urinary tract with 80% traced to the use of indwelling urinary catheters.[10] The use of urethral catheters is very common with 15% to 25% of hospitalised patients receiving a short-term indwelling urinary catheter hence high HAUTI rates are not surprising.[11-14] Calculation of how many CAUTIs may be preventable varies considerably with estimates from unpublished data ranging from 17% to 69%.[15] Given recommended

infection control measures, up to 380,000 infections and 9000 deaths related to CAUTIs per year could be prevented in the United States.[15]

Unlike other countries, Australia has not recently conducted a national point prevalence study on HAIs. The last Australian national prevalence survey for nosocomial and community-acquired infections was conducted in 1984,[16] with authors reporting a prevalence of 6.3% for HAIs with urinary tract infections contributing to 22% of infections.[16] The most recent study to report the incidence of UTIs in Australia was conducted in two hospitals, with authors reporting an incidence of 1.66%.[17]

To date, in Australia there is no specific national strategy and surveillance system in place to address HAUTIs and CAUTIs.[18-19] Several Australian States undertake surveillance activities for healthcare associated infections including the Victorian Hospital Acquired Surveillance Programme (VICNISS)); South Australian Infection Control Service (SANIT); the Centre for Healthcare Related Infection Surveillance and Prevention (CHRISP) in Queensland;[18, 20] the Tasmanian Infection Prevention and Control Unit (TIPCU) and the Hospital Infection Surveillance program in Western Australia (HISWA). These surveillance programmes differ considerably, with variability in infections surveyed and level of participation by hospitals with no mandatory participation required for hospitals within these states except New South Wales.[21] At present, there is no national or State level surveillance for HAUTIs in Australia hospitals.

To provide the foundation for a national point prevalence study and for a future prospective interventional study, we conducted a preliminary study in 6 Australian hospitals. The aims and objectives of this study were to (1) establish the point prevalence of healthcare associated urinary tract infections (HAUTI) and catheter associated urinary tract infections (CAUTI), (2) describe level and comprehensiveness of documentation related to care of urinary catheters, (3) compare two internationally accepted definitions in categorising patients with CAUTIs, namely the Health Protection Agency[22] and Centers for Disease Control and Prevention[23] definitions and (4) compare the sensitivity of microbiology laboratory data, coding data and clinical record documentation at identifying cases of HAUTIs and CAUTIs. It is expected that the findings from this study will provide policy makers and healthcare providers in Australia with HAUTI data to inform the development and implementation of targeted surveillance and high-impact HAUTI prevention programs, as well as testing a process for point prevalence of HAUTI.

Methods

Study Design. Cross sectional study

Ethics Approval. Approval for the study was obtained from four health service human research ethics committees and one university committee.

Setting and Data Sources/Measurement. Three publicly funded and three private hospitals in two Australian jurisdictions participated in the point prevalence survey. Two of the three publicly funded hospitals had greater than 400 beds each and similar case mix which included ICU, 24 hour emergency department, Haematology/Oncology units, dialysis units, Paediatrics/Women and Children, Elective and Emergency surgery. The third public hospital had fewer than 400 beds and no paediatric or dialysis services. One private hospital was a rehabilitation hospital and the other two provided acute medical and surgical services.

The survey was conducted over the first six months of 2013 in two phases. The first phase involved two public and two private hospitals and the data were collected concurrently over a single day at these sites. The second phase of the study was conducted in the remaining private and public hospital after additional funding had been obtained. Similar to Phase 1, patient records were concurrently surveyed at both sites.

For each hospital, the survey was conducted using a standardised paper-based questionnaire developed by the researchers from the CAUTI toolkit resources of the Centres for Disease Control and Prevention.[24] On the day of the point prevalence study, demographic and clinical data were obtained from patients' notes and laboratory records. Data collected included age, sex, ward speciality, presence of urinary catheter and documentation of insertion, and causative organism where appropriate of all eligible patients. For each patient who had a catheter inserted, documentation was reviewed to determine whether the need for the catheter was assessed daily, consistent with best practice recommendations.[25-26] A separate protocol paper provides more details of the study methods.[27]

The DRG (Diagnosis-related group) and ICD10 (International classification of diseases Tenth revision) coding data were retrieved by the medical records departments approximately two months after completion of the point prevalence survey. Data from the standardised paper based questionnaires were subsequently entered into a purpose designed Excel ™ database and exported into a statistical software package for analysis.

Participants. Records of patients of all ages, hospitalised on the day of the point prevalence at the study sites, were eligible for inclusion, with some exceptions. Outpatients, patients in adult mental health units, patients categorised as maintenance care type (i.e. patients waiting to be transferred to a long term care facility) and those in the emergency department during the duration of the survey were excluded.

Bias. Inter-rater reliability was enhanced by development and use of a standardised training program, with mastery being formally assessed prior to data collection, to reduce the possibility of information bias.[27] The data were collected by trained research assistants who were all registered or enrolled nurses. Before the survey dates, all research assistants were provided with a training package and underwent 2 hours of mandatory face-to-face training and assessment to assist them in collecting point prevalence data and to enhance inter-rater reliability in the application of HAUTI and CAUTI definitions and other survey procedures. The training package and program were developed using the Health Protection Scotland Education and Training Events resources.[28]

Study Size. All hospitalised persons in the participating organisation who met eligibility criteria on a given day were included in the study.

Variables. The main outcome measure was HAUTIs with CAUTI being specifically identified within this outcome. Healthcare associated infection status was defined as hospitalisation greater than 48 hours. Healthcare associated urinary tract infections and CAUTIs were ascertained by using two sets of criteria, those established by the Health Protection Agency / European Centre for Disease Prevention[22] and Control and by the Centers for Disease Control and Prevention.[23] These definitions are complex therefore flow diagrams (available as online supplementary material) were provided to research assistants' to assist them with case definitions.[27]

All patients were ascribed one or more diagnosis related codes on discharge from hospital. These codes are known as the Australian Refined Diagnosis Related Groups (AR-DRGs). This classification system enables a hospital's case mix to be described in a clinically meaningful way, enables subsequent use to identify resources required by the hospital, and forms the basis for funding in some Australian States and Territories.[29] Our study collected ICD-10 codes for infection and ICD-10 CM for procedures[30] to identify those relevant to urinary tract infections and catheterisation.

Statistical Methods. Data analysis was performed using IBM Statistics SPSS version 20. Descriptive analysis such as counts and percentages for categorical data and measures of central tendency and dispersion for continuous data was performed. The HAUTI and CAUTI point prevalence were calculated using the total patient population surveyed as the denominator. The sensitivity and positive predictive values of Centers for Disease Control and Prevention (CDC) and Health Protection Agency (HPA) surveillance definitions for HAUTI and CAUTI were compared. Cross tabulation and measures of association were applied using Chi-square tests and Fishers Exact test where appropriate to explore differences between public and private hospitals and factors significantly associated with HAUTI and CAUTI.

Results

A total of six hospitals were surveyed over a six month period and all data have been aggregated. Sub-group analysis is limited to public and private hospital status to prevent potential identification of individual participating institutions.

Participants. A total of 1109 patients were surveyed on the designated days. Of these, 505 (45.5%) were male and 604 (54.5%) were female. The median age was 64 years (interquartile range, 42-79 years). Table 1 shows the results stratified by hospital type with 905 patients surveyed from the three public hospitals and 204 from the three private hospitals. The case mix of patients based on the DRG data varied across public and private hospitals with the majority of patients managed for diseases of the musculoskeletal system and connective tissue. This was followed by diseases of the digestive system for the private hospitals and patients assigned codes based on factors influencing health status and other contacts with health services for the public hospitals such as patients attending follow-up visits and organ donors (Table 1).

INSERT TABLE 1

Prevalence of UTI. The overall prevalence of HAUTI was 1.4% (15/1109) and the prevalence of CAUTIs was 0.9 % (10). *Staphylococcus aureus* (20%) and *Candida* species (20%) were the most common pathogens identified among the patients with HAUTIs. Table 2 presents the microbial characteristics of all infections. Of the 1109 patients who were included in the survey, 1.1% met the CDC surveillance criteria for symptomatic UTI and 0.2% met the CDC criteria for asymptomatic UTI. 1.0% of the patients met the

microbiological HPA criteria and 0.2% the non-microbiological HPA criteria. There was one patient who had both Microbiological and Non-Microbiological HPA confirmation of UTI.

Tables 3 and 4 provide the comparison of surveillance definitions, the positive predictive value and sensitivity with the HPA definition classified as the "test" and the CDC definition as the "gold standard"**.**

INSERT TABLES 2, 3 & 4

Pattern of Catheter Usage. One quarter (26.3%) of all surveyed patients had a urinary catheter in place during the audit admission with the majority being indwelling catheters (88.7%). Less than half of patients surveyed had appropriate documentation, such as designation of person inserting catheter (28.8%) and reason for insertion (38.7%) (Table 5). For patients with a catheter who had the reason for insertion stated, the majority of catheters were inserted for peri-operative use for selective surgical procedures (38.9%), acute urinary retention (24.8%), and urinary output monitoring in critically ill patients (22.1%).

Of the 292 patients who had a catheter in during the audit only 7 (2.4%) patients were assigned ICD-10 codes by the medical records department as having a urinary catheter with two (0.7%) coded as having a "bladder catheter" during their admission.

INSERT TABLE 5

ICD-10 Codes. Eighty-six (7.8%) patients were coded by the medical records department as having a UTI. This coding did not take into account whether they were healthcare associated or not. Eight of the 15 patients who were ascertained to have a HAUTI based on the CDC and HPA criteria (with six of these being CAUTI) were also coded by the medical records department with an ICD-10 code for UTI diagnosis.

Discussion

There were four main findings from this study: the point prevalence of HAUTI was comparable to other studies; identification of poor standards of documentation; a suggestion that the CDC surveillance definition identified more patients with HAUTI compared to the HPA; and that clinical coding data grossly underestimates the incidence of HAUTI. Each of these findings will now be explored in more detail.

The 1.4% HAUTI point prevalence and 0.9% CAUTI point prevalence for this study are consistent with previously published reported rates, both nationally[17] and internationally.[31] Whilst this prevalence may seem low, approximately 20-30% of all HAIs are UTIs.[31-32] Extrapolating our data, we estimate that on any given day, there are approximately 1120 Australian inpatients with a HAUTI, assuming 80 000 acute hospital beds in Australia.[33] In addition, a proportion of bacteraemias are associated with UTIs and these have an associated mortality.[34-36] In the era of increasing antimicrobial resistance, particularly in Gram negative organisms, patient outcomes have the potential to worsen demonstrating a growing need for vigilance in infection prevention and HAUTI surveillance.

In this study, documentation relating to catheter insertion and management in all healthcare facilities in the study was poor. There are two main implications that follow from this – evidence based practice and health economics. For evidence based practice, the lack of documentation about who inserted catheter, catheter type and reasons for insertion, would not inspire confidence in patients about the quality of care provided or compliance with evidence based practice. For example, our survey evaluated documentation against national and international practice recommendations such as whether the ongoing need for a catheter is regularly reviewed.[25-26, 9] The biggest risk for urinary tract infection is duration of indwelling urinary catheter.[9] While it is reasonable to assume that the need for the catheter was regularly renewed for some patients and simply not documented, it is also probable that review of the need for catheter was not undertaken for many. Minimising the number of patients with catheters and the duration of catheterisation could significantly reduce the incidence of UTIs and HAIs more generally.[25] We have identified a potential gap in best practice which lends itself to future prospective interventional studies targeting improvements in urinary catheter care. We identified a further issue with poor documentation as less than 10% of urinary catheter usage was identified by ICD 10 coding. This has potential implications for funding, depending on the funding model applied.

In this study, the CDC surveillance definition identified more patients with HAUTI than the HPA definition. The difference in positive predictive value, however, was not statistically significant. Research assistants responsible for data collection overwhelmingly reported that the HPA definition was easier to use. Therefore, whilst the CDC definition is recognised as the gold standard,[37] and HPA in our study had a lower capture rate, use of the HPA definition is still likely to predict 91.7% (Confidence Interval: 64.6-98.5) of infections

diagnosed through use of the CDC definition. Therefore given the much greater ease of use of the HPA definition, we recommend the use of the HPA definition in future point prevalence studies. Any potential issue of underestimating the incidence of HAUTI using the HPA surveillance definition is less important where data are used in a quality improvement framework, as these data can be used to inform and evaluate interventions[38] rather than for diagnostic purposes or for performance management (i.e., trends overtime being most important). Other authors have commented that prospective UTI surveillance is costly and time consuming to conduct[39-40] therefore we explored alternatives to prospective UTI surveillance by comparing our prevalence data with post discharge coding data. Australian coding data does not distinguish between HAI cases and non-HAI cases. This is unlike the US coding data which provides a present on admission (POA) indicator code to inpatients helping to identify hospital acquired infections.[41] In our study ICD coding missed 50% of HAUTIs. If ICD 10 coding are used to determine the incidence of HAUTI, for reporting purposes our study suggests that such a method will grossly underestimate the number of infections, with implications for funding arrangements. This finding has also been found for other infections.[42]

Recommendations for Practice, Policy and Research

To enable the reduction of HAIs related to the genitourinary tract it is important that all health care facilities have appropriate policies and protocols for insertion of either a urethral or supra pubic catheter. It is important that these policies and protocols are evidenced based. However, prior to inserting a catheter the question of whether the patient requires this procedure should be raised. If the decision is made to insert a catheter then consideration should be given to the size of catheter to insert, the reason for the insertion and duration of time that the catheter will be in place to allow timely removal of the catheter. All information relating to the catheter and its care should also be documented in the notes (this could be in the form of a sticker to be easily found in the notes) and on the care plan.

Documentation by medical and nursing staff is important for the day to day infection prevention and control and to alert staff to ensure timely removal of urinary catheters. If a CAUTI is diagnosed then documentation should include: causative organism, what antibiotics have been commenced, and whether the antibiotics are appropriate to treat that microorganism. Other relevant notes are actions taken, such as removal or replacement of the catheter. One potential way of improving compliance with clinical guidelines and

documentation at both the insertion and maintenance phases of catheter care, is the use of a checklist or 'bundle' approach.[43]

To improve health outcomes for patients it is important to continue exploration of ways to identify and reduce HAUTIs and CAUTIs. We have shown it is feasible to conduct prevalence studies across 6 health institutions and funding should be sought for a national point prevalence of UTIs as demonstrated by countries already undertaking this.[4] Analysing national point prevalence data will provide a baseline for intervention studies that test care bundles to reduce HAUTIs and their sequelae.[43]

Currently, it appears that ICD10 coding is not a reliable way of monitoring prevalence of HAUTI, at least in some healthcare facilities. Our findings were consistent with other HAI coding.[42] This potential under-reporting of infections has implications for policy and healthcare reimbursement, although in some US jurisdictions, healthcare facilities are penalised for HAIs rather than being reimbursed.[44-45] We recommend that facilities undertake audits to compare clinical and coding data periodically.

There are some limitations in our study. The survey was conducted in only six hospitals within two states and territories limiting the generalisability of the results. However, there were significant findings enabling recommendations for a future national point prevalence study to be made. Another limitation of our study is the reliance on clinical records and not direct diagnosis. This was overcome by using research assistants with some prior clinical and infection control knowledge, for example registered nurses, for data collection. The research assistants were adequately trained and the outcome of the training was evaluated by post training case study assessments.[27] Such a process also enhanced inter-rater reliability. There were no previous HAUTI and CAUTI rates for comparison within the study sites as they had not collected this type of data before. As earlier stated, the findings can now be used to make recommendations for conducting point prevalence surveys in a standardised manner to facilitate comparisons over time within individual health facilities. The aggregation of data from all participating hospitals for analysis may be a further limitation. The size and scope of services in these hospitals varies and this in turn presents variations in risk. Regardless, the process we employed in common in point prevalence studies.[8,9] Despite the study limitations, this survey has identified some priority areas including efficacy of documentation practices related to care of urinary catheters which are key to preventing CAUTIs. There were also no obvious sources of bias.

ConclusionTo tackle the issue of CAUTIs and other HAIs in Australia, it is imperative to develop a national surveillance system based on validated methods and definitions which have been found to be effective in other developed countries. This study provides a foundation for the development of a national infection control initiative in our rapidly evolving healthcare environment and associated challenges with drug resistance.

Author contribution

All authors contributed to design of study and development of instruments. BM, WB and OF supervised data collection. OF & AG conducted initial data analysis. All authors contributed to further data analysis and manuscript preparation.

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Competing Interests

None.

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Data sharing statement

No additional data available.

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Tables

Table 1. Patient Demographics

Characteristic			Private Hospitals *n*(%) *n* = 204	Public Hospitals *n*(%) *n* = 905	Total (%) *N* = 1109
Age Category (in years)		<35	21 (10.3)	210 (23.2)	231 (20.8)
		35-64	46 (22.5)	292 (32.3)	338 (30.5)
		65-84	82 (40.2)	299 (33.0)	381 (34.4)
		≥85	55 (27.0)	104 (11.5)	159 (14.3)
Gender		Male	79 (38.7)	426 (47.1)	505 (45.5)
		Female	125 (61.3)	479 (52.9)	604 (54.5)
Ward Specialty	Surgery		69 (33.8)	300 (33.1)	369 (33.3)
	General Medicine		55 (27.0)	273 (30.2)	328 (29.6)
	General Practice/Rehabilitation/Geriatric Medicine		37 (18.1)	100 (11.0)	137 (12.4)
	Obstetrics/Gynaecology		17 (8.3)	86 (9.5)	103 (9.3)
	Oncology		17 (8.3)	55 (6.1)	72 (6.5)
	Paediatrics		7 (3.4)	63 (7.0)	70 (6.3)
	High Dependency Unit		0 (0)	28 (3.1)	28 (2.5)
	Other (Pain management)		2 (1.0)	0 (0)	2 (0.2)
DRG*	Diseases of the musculoskeletal system and connective tissue		41 (20.1)	130 (14.4)	171 (15.4)
	Factors influencing health status and other contacts with health services		5 (2.5)	89 (9.8)	94 (8.5)
	Diseases of the digestive system		18 (8.8)	63 (7.0)	81 (7.3)
	Diseases of the circulatory system		8 (3.9)	65 (7.2)	73 (6.6)
	Diseases of the respiratory system		14 (6.9)	47 (5.2)	61 (5.5)
	Pregnancy, childbirth and pueperium		11 (5.4)	47 (5.2)	58 (5.2)
	Diseases of the nervous system		15 (7.4)	39 (4.3)	54 (4.9)
	Newborns and other neonates		16 (7.8)	27 (3.0)	43 (3.9)
	Major procedures where the principal diagnosis may be associated with any Major		16 (7.8)	18 (2.0)	34 (3.1)

	Diagnostic Category			
	Diseases of the kidney and urinary tract	8 (3.9)	25 (2.8)	33 (3.0)
	Other¥	38 (18.6)	133 (14.7)	171 (15.4)
	Missing‡	14 (6.9)	222 (24.5)	236 (21.3)

*DRG = Diagnosis Related Group

¥ = Diseases of the skin, subcutaneous tissue and breast; Injuries, poisoning and toxic effects of drugs; Diseases of the hepatobiliary system and pancreas; Neoplastic Diseases (haematological and solid neoplasms); Infectious and parasitic diseases; Endocrine, nutritional and metabolic diseases and disorders; Diseases of the ear, nose, mouth, and throat; Diseases of the female reproductive system; Diseases of the male reproductive system; Mental diseases and disorders; Diseases of the blood and blood forming organs and immunological diseases; Diseases of the eye; Burns

‡ = Missing DRG data includes all patients in one public hospital

Table 2. Microbial Characteristics for non-CAUTI HAUTIs and CAUTIs

Type of Organism		Non-CAUTI *N* = 5	ICD10 code YES/NO	CAUTI *N* = 10	ICD code YES/NO	TOTAL *N* = 15
Gram positive	*Enterococcus* species	1	no	1	no	2
	Staphylococcus aureus	1	yes	2	1 yes 1 no	3
Gram negative	*Escherichia coli*	0	NA	2	yes	2
	Klebsiella species	0	NA	1	no	1
	Proteus species	2	no	0	NA	2
	Pseudomonas species	1	no	0	NA	1
Fungi	*Candida* species	0	NA	3	1 yes 2 no	3
Organism not listed		0	NA	1	yes	1

NA = Not Applicable

Table 3. Comparison of CDC and HPA Surveillance definitions

	CDC* POSITIVE	CDC NEGATIVE	TOTAL
HPA POSITIVE	11 (1.0%)	1 (0.1%)	12 (1.1%)
HPA NEGATIVE	3 (0.3%)	1094 (98.6)	1097 (98.9%)
TOTAL	14 (1.3%)	1095 (98.7%)	1109 (100.0%)

*NB: For the purposes of calculation, the CDC definition was considered to be gold standard

The percentages represent the number of people identified as having a HAUTI based on a specific criteria divided by the total number of people surveyed.

Table 4. Estimates of the Positive Predictive Value, Sensitivity and Confidence Intervals of the HPA surveillance definition compared to the CDC definition

Result	Value (%)	Confidence Interval
Sensitivity	78.57	(52.41, 92.43)
Specificity	99.91	(99.48, 99.98)
Positive Predictive Value	91.67	(64.61, 98.51)
Negative Predictive Value	99.73	(99.2, 99.91)
Diagnostic Accuracy	99.64	(99.08, 99.86)

Table 5. Catheter Information

Characteristic		Private Hospitals (%) *n* = 60	Public Hospitals (%) *n* = 232	Total (%) *N* = 292
Catheter at any time During this Admission	Yes	60 (29.4)	232 (25.6)	292 (26.3)
	No	144 (70.6)	673 (74.4)	817 (73.7)
Presence of Catheter	Currently insitu	29 (48.3)	146 (62.9)*	175 (59.9)
	Catheter inserted but removed during admission	31 (51.7)	85 (36.7)	116 (39.7)
	Intermittent	0 (0)	1 (0.4)	1 (0.4)
Catheter Location	Indwelling	54 (90.0)	205 (88.4)	259 (88.7)
	Suprapubic	4 (6.6)	10 (4.3)	14 (4.8)
	Intermittent	0 (0)	2 (0.9)	2 (0.7)
	Both indwelling and suprapubic	1 (1.7)	0 (0)	1 (0.3)
	Not documented	1 (1.7)	15 (6.4)	16 (5.5)
Catheter Type	Silver alloy	0 (0)	1 (0.4)	1 (0.3)
	Silicone	7 (11.7)	55 (23.7)	62 (21.2)
	Antimicrobial	0 (0)	0 (0)	0 (0)
	Foley	0 (0)	19 (8.2)	19 (6.5)
	Latex	0 (0)	2 (0.9)	2 (0.7)
	Other	0 (0)	11 (7.8)	11 (3.8)
	Not documented	53 (88.3)	144 (62.1)	197 (67.5)
Catheter Size (French Grade)	6	0 (0)	1 (0.4)	1 (0.3)
	10	0 (0)	1 (0.4)	1 (0.3)
	12	16 (26.7)	16 (6.9)	32 (11.0)
	14	10 (16.7)	54 (23.3)	64 (22.0)
	16	8 (13.3)	19 (8.2)	27 (9.2)
	18	0 (0)	3 (1.3)	3 (1.0)
	20	2 (3.3)	2 (0.9)	4 (1.4)
	22	0 (0)	1 (0.4)	1 (0.3)
	24	1 (1.7)‡	0 (0)	1 (0.3)

	Not documented	24 (40.0)	135 (58.2)	159 (54.5)
Inserted by	Nurse	5 (8.3)	46 (19.8)	51 (17.5)
	Doctor	13 (21.7)	18 (7.8)	31 (10.6)
	Other (student)	1 (1.7)	1 (0.4)	2 (0.7)
	Not documented	41 (68.3)	167 (72.0)	208 (71.2)
Reason for Insertion Stated	Yes	36 (60.0)	77 (33.2)	113 (38.7)
	No	24 (40.0)	155 (66.8)	179 (61.3)
Cleaning Solution	Chlorhexidine	0 (0)	1 (0.4)	1 (0.3)
	Unknown	60 (100)	231 (99.6)	291 (99.7)
Ongoing Need for Catheter Reviewed (days)	0	34 (56.7)	157 (67.7)	191 (65.4)
	1	10 (16.7)	35 (15.1)	45 (15.4)
	2-3	5 (8.3)	24 (10.3)	29 (9.9)
	4-5	1 (1.7)	3 (1.3)	4 (1.4)
	>5	0 (0)	3 (1.3)	3 (1.0)
	Not documented	10 (16.7)	10 (4.3)	20 (6.8)

*It is unknown if catheter still insitu for 3 of these participants at time of survey.

‡1 patient had both indwelling and suprapubic catheters of 2 different sizes.

Health Protection Agency and Centers for Disease Control and Prevention definitions for Urinary Tract Infection

HPA definitions*

Healthcare associated if onset:

- Day 3 of admission onwards (>48 hours) or
- Day 1 or Day 2 AND patient discharged from hospital in preceding 48 hours
- Day 1 or day 2 AND patient has relevant device inserted on this admission prior to onset

CAUTI

If indwelling catheter insitu at time of infection onset or removed in previous >48 prior to symptom onset

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Microbiologically confirmed symptomatic UTI

- Patient has at least one of the following signs of symptoms with no other recognized cause: fever (>38°C), urgency, frequency, dysuria, or suprapubic tenderness

and

- Patient has a positive urine culture, that is, ≥ 10^5 microorganisms per ml of urine with no more than 2 species of microorganisms.

Not microbiologically confirmed symptomatic UTI

- Patient has at least two of the following with no other recognized cause: fever (>38°C), urgency, frequency, dysuria, or suprapubic tenderness

and
at **least one** of the following:

- Positive dipstick for leukocyte esterase and/or nitrate
- Pyuria urine specimen with ≥10 WBC/ml or ≥ 3 WBC/high-power field of unspun urine
- Organisms seen on Gram stain of unspun urine
- At least two urine cultures with repeated isolation of the same uropathogen (gram-negative bacteria or *S. saprophyticus*) with ≥ 10^2 colonies/ml urine in nonvoided specimens
- ≤10^5 colonies/ml of a single uropathogen (gram-negative bacteria or *S. saprophyticus*) in A patient being treated with effective antimicrobial agent for a urinary infection
- Physician diagnosis of a urinary tract infection
- Physician institutes appropriate therapy for a urinary infection

*NOTE: bloodstream infections secondary to asymptomatic bacteriuria are not included

Source: Health Protection Agency. Fourth National Point Prevalence Survey on Healthcare Associated Infections and First National Point Prevalence Survey on Antimicrobial Use and Quality Indicators in England 2011.

CDC definitions

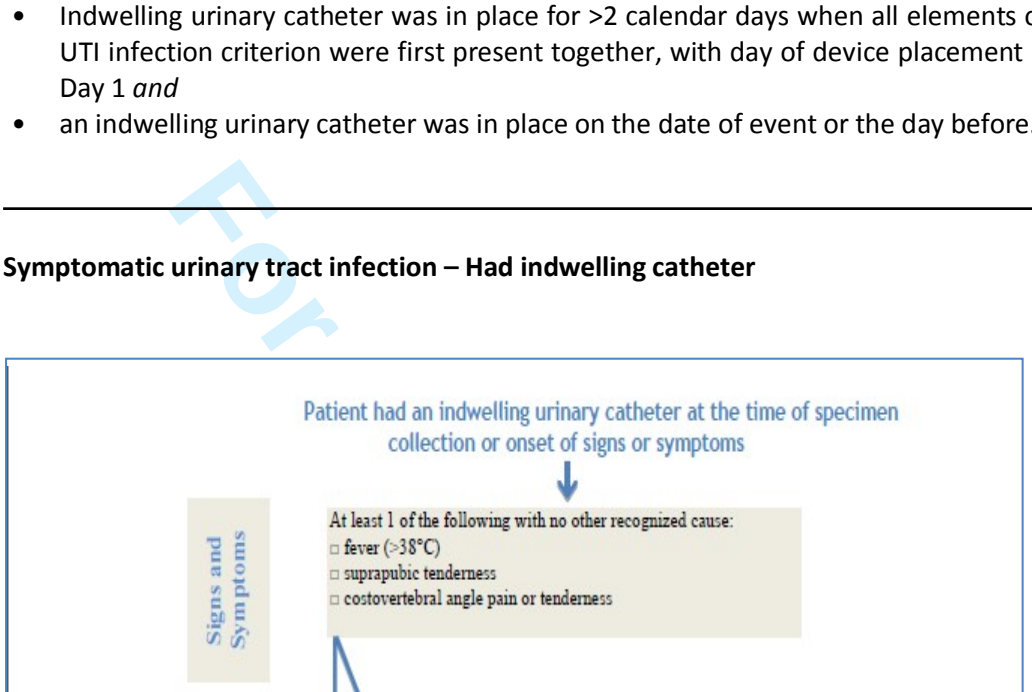
Healthcare associated if onset:

- after the 3rd hospital day (day of hospital admission is day 1) (>48 hours)

CAUTI

- Indwelling urinary catheter was in place for >2 calendar days when all elements of the UTI infection criterion were first present together, with day of device placement being Day 1 *and*
- an indwelling urinary catheter was in place on the date of event or the day before.

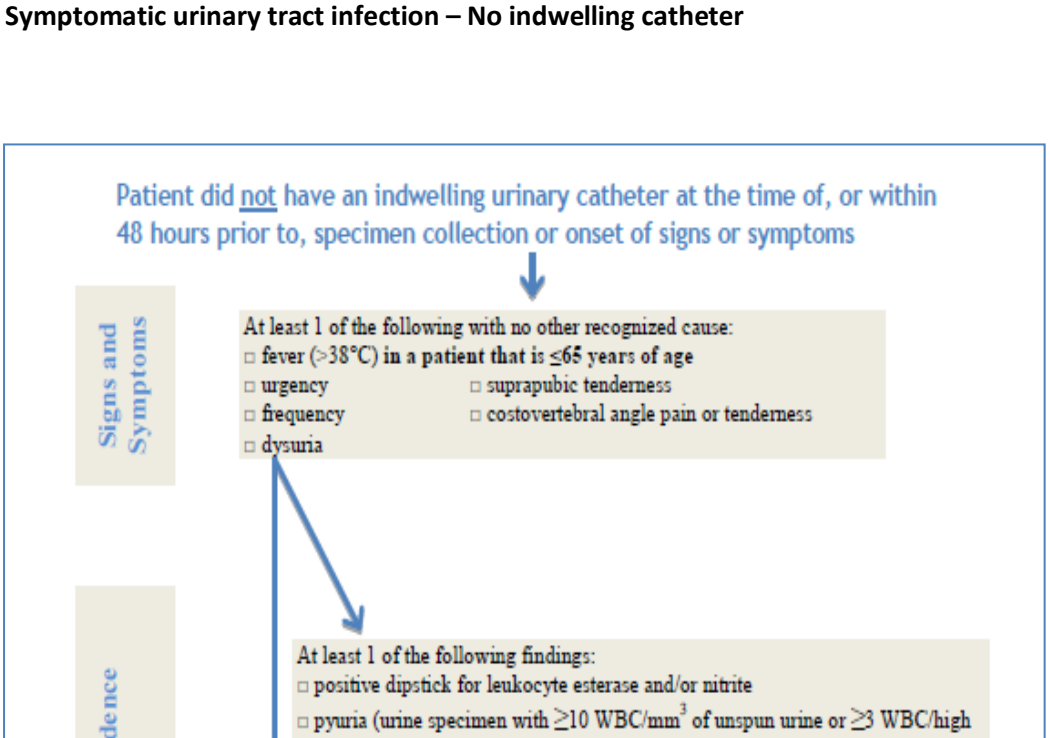
Symptomatic urinary tract infection – Had indwelling catheter



Source: Centres for Disease Control and Prevention. NHSN Patient Safety Component Manual 2012.

CDC definitions

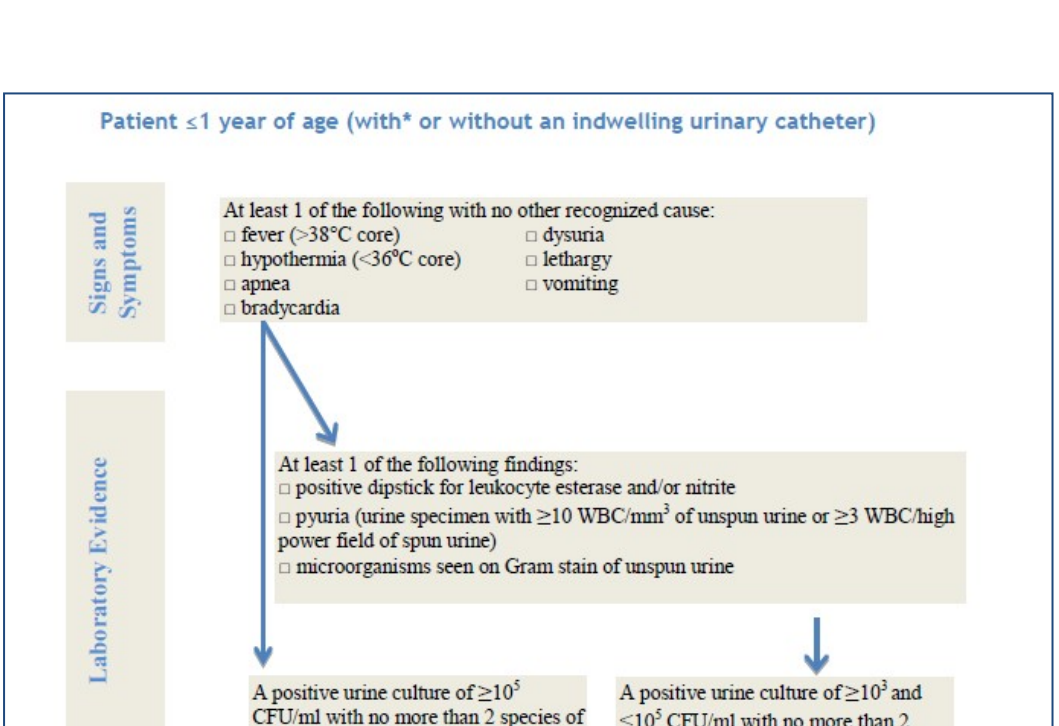
Symptomatic urinary tract infection – No indwelling catheter



Source: Centres for Disease Control and Prevention. NHSN Patient Safety Component Manual 2012.

CDC definitions

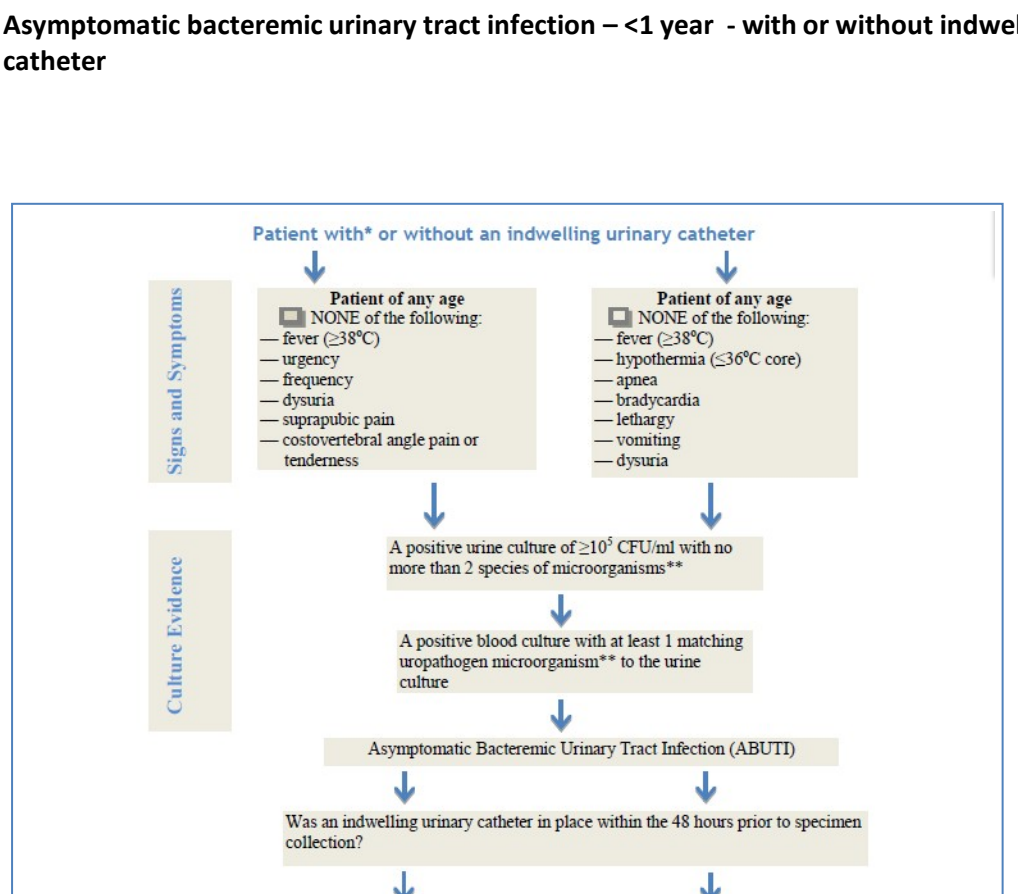
Symptomatic urinary tract infection – <1 year - with or without indwelling catheter



Source: Centres for Disease Control and Prevention. NHSN Patient Safety Component Manual 2012.

CDC definitions

Asymptomatic bacteremic urinary tract infection – <1 year - with or without indwelling catheter



Source: Centres for Disease Control and Prevention. NHSN Patient Safety Component Manual 2012.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract✓
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found✓
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported✓
Objectives	3	State specific objectives, including any prespecified hypotheses✓
Methods		
Study design	4	Present key elements of study design early in the paper✓
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection✓
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants✓
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable✓
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group✓
Bias	9	Describe any efforts to address potential sources of bias✓
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why✓
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding✓
		(*b*) Describe any methods used to examine subgroups and interactions✓
		(*c*) Explain how missing data were addressed✓
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy Not Applicable
		(*e*) Describe any sensitivity analyses✓

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders✓
		(b) Indicate number of participants with missing data for each variable of interest✓
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures✓
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized✓
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period Not Applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses✓
Discussion		
Key results	18	Summarise key results with reference to study objectives✓
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias✓
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence✓
Generalisability	21	Discuss the generalisability (external validity) of the study results✓
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based✓

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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A Point Prevalence Cross Sectional Study of Health Care Associated Urinary Tract Infections in Six Australian Hospitals

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Word count: 3574

Abstract

Objectives: Urinary tract infections account for over 30% of healthcare associated infections. The aim of this study was to determine healthcare associated urinary tract infection (HAUTI) and catheter associated urinary tract infection (CAUTI) point prevalence in six Australian hospitals to inform a national point prevalence process and compare two internationally accepted HAUTI definitions. We also described the level and comprehensiveness of clinical record documentation, microbiology laboratory and coding data at identifying HAUTIs and CAUTIs.

Setting: Data were collected from three public and three private Australian hospitals over the first six months of 2013.

Participants: A total of 1109 patients were surveyed. Records of patients of all ages, hospitalised on the day of the point prevalence at the study sites were eligible for inclusion. Outpatients, patients in adult mental health units, patients categorised as maintenance care type (i.e. patients waiting to be transferred to a long term care facility) and those in the emergency department during the duration of the survey were excluded.

Outcome measures: The primary outcome measures were the HAUTI and CAUTI point prevalence.

Results: Overall HAUTI and CAUTI prevalence was 1.4% (15/1109) and 0.9% (10/1109) respectively. *Staphylococcus aureus* and *Candida species* were the most common pathogens. One quarter (26.3%) of patients had a urinary catheter and fewer than half had appropriate documentation. Eight of the 15 patients ascertained to have a HAUTI based on clinical records (six being CAUTI) were coded by the medical records department with an ICD-10 code for UTI diagnosis. The Health protection Agency Surveillance definition had a positive predictive value of 91.67% (confidence interval 64.61-98.51) compared against the Centers for Disease Control and Prevention definition.

Conclusions: These study results provide a foundation for a national Australian point prevalence study and inform the development and implementation of targeted HAI surveillance more broadly.

Strengths and limitations of this study

- This is the first study to compare two internationally accepted definitions in categorising patients with CAUTIs, namely the Health Protection Agency and Centers for Disease Control and Prevention definitions.
- This study demonstrates the feasibility of conducting point prevalence surveys of HAUTIs in a standardised manner to facilitate comparisons over time within individual health facilities.
- A limitation of this study is that the survey was conducted in only six hospitals within two states and territories limiting the generalisability of the results. However, there were significant findings enabling recommendations for a future national point prevalence study to be made.

Background/Rationale

Healthcare associated infections (HAIs) have considerable medical consequences and pose a significant problem for patient safety.[1] A recent systematic review and meta-analysis of 220 international articles indicated that the prevalence and incidence of HAIs is 10% and 7% per 100 patients, respectively.[2] Further, the prevalence of infected patients is 11% per 100 patients.[2] Fifty percent of the reviewed prevalence studies stated magnitudes of infected patients higher than 10% per 100 patients.[2] The Centers for Disease Control and Prevention estimates that 1.7 million people develop HAIs and 100,000 people die of HAI related complications each year in the United States.[3] The first European Union (EU)-wide point prevalence survey (PPS) of healthcare-associated infections and antimicrobial use in hospitals conducted in 2011–2012, estimated that on any given day, about 80 000 patients have at least one HAI, i.e. one in 18 patients in a European hospital has an HAI.[4] The studies support the view that HAIs are the most common complication of hospitalisation. This concept is not new, as demonstrated in a landmark paper "*To Err is Human: Building a Safer Health System*" published in 1999 by the Institute of Medicine (IOM).[5] However, these infections are a potentially preventable adverse event rather than an unpredictable complication and it is possible to significantly reduce the rate of HAIs through effective infection prevention and control.[6]

HAIs could be prevented by sustained, multifaceted infection prevention and control programmes, including the Hawthorne effect of surveillance.[4] Although prospective active surveillance is considered to be the gold standard for surveillance, prevalence surveys are quite useful as they can provide baseline information about the occurrence and distribution of HAI, are generally easy to conduct, relatively inexpensive and not too time-consuming.[7-8] National surveillance of HAI has been introduced in North America and in many European countries and national prevalence surveys of HAI are also increasingly common.[8]

Urinary tract infections account for more than 30% of HAIs reported by acute care hospitals.[9] Virtually all healthcare-associated urinary tract infections (HAUTIs) are caused by instrumentation of the urinary tract with 80% traced to the use of indwelling urinary catheters.[10] The use of urethral catheters is very common with 15% to 25% of hospitalised patients receiving a short-term indwelling urinary catheter hence high HAUTI rates are not surprising.[11-14] Calculation of how many CAUTIs may be preventable varies considerably with estimates from unpublished data ranging from 17% to 69%.[15] Given recommended

infection control measures, up to 380,000 infections and 9000 deaths related to CAUTIs per year could be prevented in the United States.[15]

Unlike other countries, Australia has not recently conducted a national point prevalence study on HAIs. The last Australian national prevalence survey for nosocomial and community-acquired infections was conducted in 1984,[16] with authors reporting a prevalence of 6.3% for HAIs with urinary tract infections contributing to 22% of infections.[16] The most recent study to report the incidence of UTIs in Australia was conducted in two hospitals, with authors reporting an incidence of 1.66%.[17]

To date, in Australia there is no specific national strategy and surveillance system in place to address HAUTIs and CAUTIs.[18-19] Several Australian States undertake surveillance activities for healthcare associated infections including the Victorian Hospital Acquired Surveillance Programme (VICNISS)); South Australian Infection Control Service (SANIT); the Centre for Healthcare Related Infection Surveillance and Prevention (CHRISP) in Queensland;[18, 20] the Tasmanian Infection Prevention and Control Unit (TIPCU) and the Hospital Infection Surveillance program in Western Australia (HISWA). These surveillance programmes differ considerably, with variability in infections surveyed and level of participation by hospitals with no mandatory participation required for hospitals within these states except New South Wales.[21] At present, there is no national or State level surveillance for HAUTIs in Australia hospitals.

To provide the foundation for a national point prevalence study and for a future prospective interventional study, we conducted a preliminary study in 6 Australian hospitals. The aims and objectives of this study were to (1) establish the point prevalence of healthcare associated urinary tract infections (HAUTI) and catheter associated urinary tract infections (CAUTI), (2) describe level and comprehensiveness of documentation related to care of urinary catheters, (3) compare two internationally accepted definitions in categorising patients with CAUTIs, namely the Health Protection Agency (HPA)[22] and Centers for Disease Control and Prevention (CDC)[23] definitions and (4) compare the sensitivity of microbiology laboratory data, coding data and clinical record documentation at identifying cases of HAUTIs and CAUTIs. It is expected that the findings from this study will provide policy makers and healthcare providers in Australia with HAUTI data to inform the development and implementation of targeted surveillance and high-impact HAUTI prevention programs, as well as testing a process for point prevalence of HAUTI.

Methods

Study Design. Cross sectional study

Ethics Approval. Approval for the study was obtained from four health service human research ethics committees and one university committee.

Setting and Data Sources/Measurement. Three publicly funded and three private hospitals in two Australian jurisdictions participated in the point prevalence survey. Two of the three publicly funded hospitals had greater than 400 beds each and similar case mix which included ICU, 24 hour emergency department, Haematology/Oncology units, dialysis units, Paediatrics/Women and Children, Elective and Emergency surgery. The third public hospital had fewer than 400 beds and no paediatric or dialysis services. One private hospital was a rehabilitation hospital and the other two provided acute medical and surgical services.

The survey was conducted over the first six months of 2013 in two phases. The first phase involved two public and two private hospitals and the data were collected concurrently over a single day at these sites. The second phase of the study was conducted in the remaining private and public hospital after additional funding had been obtained. Similar to Phase 1, patient records were concurrently surveyed at both sites.

For each hospital, the survey was conducted using a standardised paper-based questionnaire developed by the researchers from the CAUTI toolkit resources of the CDC .[24] On the day of the point prevalence study, demographic and clinical data were obtained from patients' notes and laboratory records. Data collected included age, sex, ward speciality, presence of urinary catheter and documentation of insertion, and causative organism where appropriate of all eligible patients. For each patient who had a catheter inserted, documentation was reviewed to determine whether the need for the catheter was assessed daily, consistent with best practice recommendations.[25-26] A separate protocol paper provides more details of the study methods.[27]

The DRG (Diagnosis-related group) and ICD10 (International classification of diseases Tenth revision) coding data were retrieved by the medical records departments approximately two months after completion of the point prevalence survey. Data from the standardised paper based questionnaires were subsequently entered into a purpose designed Excel ™ database and exported into a statistical software package for analysis.

Participants. Records of patients of all ages, hospitalised on the day of the point prevalence at the study sites, were eligible for inclusion, with some exceptions. Outpatients, patients in adult mental health units, patients categorised as maintenance care type (i.e. patients waiting to be transferred to a long term care facility) and those in the emergency department during the duration of the survey were excluded.

Bias. Inter-rater reliability was enhanced by development and use of a standardised training program, with mastery being formally assessed prior to data collection, to reduce the possibility of information bias.[27] The data were collected by trained research assistants who were all registered or enrolled nurses. Before the survey dates, all research assistants were provided with a training package and underwent 2 hours of mandatory face-to-face training and assessment to assist them in collecting point prevalence data and to enhance inter-rater reliability in the application of HAUTI and CAUTI definitions and other survey procedures. The training package and program were developed using the Health Protection Scotland Education and Training Events resources.[28]

Study Size. All hospitalised persons in the participating organisation who met eligibility criteria on a given day were included in the study.

Variables. The main outcome measure was HAUTIs with CAUTI being specifically identified within this outcome. Healthcare associated infection status was defined as hospitalisation greater than 48 hours. Healthcare associated urinary tract infections and CAUTIs were ascertained by using two sets of criteria, those established by the HPA / European Centre for Disease Prevention and Control[22] and by the CDC .[23] These definitions are complex therefore flow diagrams (available as online supplementary material) were provided to research assistants' to assist them with case definitions.[27]

All patients were ascribed one or more diagnosis related codes on discharge from hospital. These codes are known as the Australian Refined DRGs. This classification system enables a hospital's case mix to be described in a clinically meaningful way, enables subsequent use to identify resources required by the hospital, and forms the basis for funding in some Australian States and Territories.[29] Our study collected ICD-10 codes for infection and ICD-10 CM for procedures[30] to identify those relevant to urinary tract infections and catheterisation.

Statistical Methods. Data analysis was performed using IBM Statistics SPSS version 20. Descriptive analysis such as counts and percentages for categorical data and measures of

central tendency and dispersion for continuous data was performed. The HAUTI and CAUTI point prevalence were calculated using the total patient population surveyed as the denominator. The sensitivity and positive predictive values of CDC and HPA surveillance definitions for HAUTI and CAUTI were compared. Cross tabulation and measures of association were applied using Chi-square tests and Fishers Exact test where appropriate to explore differences between public and private hospitals and factors significantly associated with HAUTI and CAUTI.

Results

A total of six hospitals were surveyed over a six month period and all data have been aggregated. Sub-group analysis is limited to public and private hospital status to prevent potential identification of individual participating institutions.

Participants. A total of 1109 patients were surveyed on the designated days. Of these, 505 (45.5%) were male and 604 (54.5%) were female. The median age was 64 years (interquartile range, 42-79 years). Table 1 shows the results stratified by hospital type with 905 patients surveyed from the three public hospitals and 204 from the three private hospitals. The case mix of patients based on the DRG data varied across public and private hospitals with the majority of patients managed for diseases of the musculoskeletal system and connective tissue. This was followed by diseases of the digestive system for the private hospitals and patients assigned codes based on factors influencing health status and other contacts with health services for the public hospitals such as patients attending follow-up visits and organ donors (Table 1).

INSERT TABLE 1

Prevalence of UTI. The overall prevalence of HAUTI was 1.4% (15/1109) and the prevalence of CAUTIs was 0.9 % (10). *Staphylococcus aureus* (20%) and *Candida* species (20%) were the most common pathogens identified among the patients with HAUTIs. Table 2 presents the microbial characteristics of all infections. Of the 1109 patients who were included in the survey, 1.1% met the CDC surveillance criteria for symptomatic UTI and 0.2% met the CDC criteria for asymptomatic UTI. 1.0% of the patients met the microbiological HPA criteria and 0.2% the non-microbiological HPA criteria. There was one patient who had both Microbiological and Non-Microbiological HPA confirmation of UTI.

Tables 3 and 4 provide the comparison of surveillance definitions, the positive predictive value and sensitivity with the HPA definition classified as the "test" and the CDC definition as the "gold standard".

INSERT TABLES 2, 3 & 4

Pattern of Catheter Usage. One quarter (26.3%) of all surveyed patients had a urinary catheter in place during the audit admission with the majority being indwelling catheters (88.7%). Less than half of patients surveyed had appropriate documentation, such as designation of person inserting catheter (28.8%) and reason for insertion (38.7%) (Table 5). For patients with a catheter who had the reason for insertion stated, the majority of catheters were inserted for peri-operative use for selective surgical procedures (38.9%), acute urinary retention (24.8%), and urinary output monitoring in critically ill patients (22.1%).

Of the 292 patients who had a catheter in during the audit only 7 (2.4%) patients were assigned ICD-10 codes by the medical records department as having a urinary catheter with two (0.7%) coded as having a "bladder catheter" during their admission.

INSERT TABLE 5

ICD-10 Codes. Eighty-six (7.8%) patients were coded by the medical records department as having a UTI. This coding did not take into account whether they were healthcare associated or not. Eight of the 15 patients who were ascertained to have a HAUTI based on the CDC and HPA criteria (with six of these being CAUTI) were also coded by the medical records department with an ICD-10 code for UTI diagnosis.

Discussion

There were four main findings from this study: the point prevalence of HAUTI was comparable to other studies; identification of poor standards of documentation; a suggestion that the CDC surveillance definition identified more patients with HAUTI compared to the HPA; and that clinical coding data grossly underestimates the incidence of HAUTI. Each of these findings will now be explored in more detail.

The 1.4% HAUTI point prevalence and 0.9% CAUTI point prevalence for this study are consistent with previously published reported rates, both nationally[17] and internationally.[31] Whilst this prevalence may seem low, approximately 20-30% of all HAIs

are UTIs.[31-32] Extrapolating our data, we estimate that on any given day, there are approximately 1120 Australian inpatients with a HAUTI, assuming 80 000 acute hospital beds in Australia.[33] In addition, a proportion of bacteraemias are associated with UTIs and these have an associated mortality.[34-36] In the era of increasing antimicrobial resistance, particularly in Gram negative organisms, patient outcomes have the potential to worsen demonstrating a growing need for vigilance in infection prevention and HAUTI surveillance.

In this study, documentation relating to catheter insertion and management in all healthcare facilities in the study was poor. There are two main implications that follow from this – evidence based practice and health economics. For evidence based practice, the lack of documentation about who inserted catheter, catheter type and reasons for insertion, would not inspire confidence in patients about the quality of care provided or compliance with evidence based practice. For example, our survey evaluated documentation against national and international practice recommendations such as whether the ongoing need for a catheter is regularly reviewed.[25-26, 9] The biggest risk for urinary tract infection is duration of indwelling urinary catheter.[9] While it is reasonable to assume that the need for the catheter was regularly renewed for some patients and simply not documented, it is also probable that review of the need for catheter was not undertaken for many. Minimising the number of patients with catheters and the duration of catheterisation could significantly reduce the incidence of UTIs and HAIs more generally.[25] We have identified a potential gap in best practice which lends itself to future prospective interventional studies targeting improvements in urinary catheter care. We identified a further issue with poor documentation as less than 10% of urinary catheter usage was identified by ICD 10 coding. This has potential implications for funding, depending on the funding model applied.

In this study, the CDC surveillance definition identified more patients with HAUTI than the HPA definition. The difference in positive predictive value, however, was not statistically significant. Research assistants responsible for data collection overwhelmingly reported that the HPA definition was easier to use. Therefore, whilst the CDC definition is recognised as the gold standard,[37] and HPA in our study had a lower capture rate, use of the HPA definition is still likely to predict 91.7% (Confidence Interval: 64.6-98.5) of infections diagnosed through use of the CDC definition. Therefore given the much greater ease of use of the HPA definition, we recommend the use of the HPA definition in future point prevalence studies. Any potential issue of underestimating the incidence of HAUTI using the HPA

surveillance definition is less important where data are used in a quality improvement framework, as these data can be used to inform and evaluate interventions[38] rather than for diagnostic purposes or for performance management (i.e., trends overtime being most important). Other authors have commented that prospective UTI surveillance is costly and time consuming to conduct[39-40] therefore we explored alternatives to prospective UTI surveillance by comparing our prevalence data with post discharge coding data. Australian coding data does not distinguish between HAI cases and non-HAI cases. This is unlike the US coding data which provides a present on admission (POA) indicator code to inpatients helping to identify hospital acquired infections.[41] In our study ICD coding missed 50% of HAUTIs. If ICD 10 coding are used to determine the incidence of HAUTI, for reporting purposes our study suggests that such a method will grossly underestimate the number of infections, with implications for funding arrangements. This finding has also been found for other infections.[42]

Recommendations for Practice, Policy and Research

To enable the reduction of HAIs related to the genitourinary tract it is important that all health care facilities have appropriate policies and protocols for insertion of either a urethral or supra pubic catheter. It is important that these policies and protocols are evidenced based. However, prior to inserting a catheter the question of whether the patient requires this procedure should be raised. If the decision is made to insert a catheter then consideration should be given to the size of catheter to insert, the reason for the insertion and duration of time that the catheter will be in place to allow timely removal of the catheter. All information relating to the catheter and its care should also be documented in the notes (this could be in the form of a sticker to be easily found in the notes) and on the care plan.

Documentation by medical and nursing staff is important for the day to day infection prevention and control and to alert staff to ensure timely removal of urinary catheters. If a CAUTI is diagnosed then documentation should include: causative organism, what antibiotics have been commenced, and whether the antibiotics are appropriate to treat that microorganism. Other relevant notes are actions taken, such as removal or replacement of the catheter. One potential way of improving compliance with clinical guidelines and documentation at both the insertion and maintenance phases of catheter care, is the use of a checklist or 'bundle' approach.[43]

To improve health outcomes for patients it is important to continue exploration of ways to identify and reduce HAUTIs and CAUTIs. We have shown it is feasible to conduct prevalence studies across 6 health institutions and funding should be sought for a national point prevalence of UTIs as demonstrated by countries already undertaking this.[4] Analysing national point prevalence data will provide a baseline for intervention studies that test care bundles to reduce HAUTIs and their sequelae.[43]

Currently, it appears that ICD10 coding is not a reliable way of monitoring prevalence of HAUTI, at least in some healthcare facilities. Our findings were consistent with other HAI coding.[42] This potential under-reporting of infections has implications for policy and healthcare reimbursement, although in some US jurisdictions, healthcare facilities are penalised for HAIs rather than being reimbursed.[44-45] We recommend that facilities undertake audits to compare clinical and coding data periodically.

There are some limitations in our study. The survey was conducted in only six hospitals within two states and territories limiting the generalisability of the results. However, there were significant findings enabling recommendations for a future national point prevalence study to be made. Another limitation of our study is the reliance on clinical records and not direct diagnosis. This was overcome by using research assistants with some prior clinical and infection control knowledge, for example registered nurses, for data collection. The research assistants were adequately trained and the outcome of the training was evaluated by post training case study assessments.[27] Such a process also enhanced inter-rater reliability. There were no previous HAUTI and CAUTI rates for comparison within the study sites as they had not collected this type of data before. As earlier stated, the findings can now be used to make recommendations for conducting point prevalence surveys in a standardised manner to facilitate comparisons over time within individual health facilities. The aggregation of data from all participating hospitals for analysis may be a further limitation. The size and scope of services in these hospitals varies and this in turn presents variations in risk. Regardless, the process we employed is common in point prevalence studies, which only capture data at a specific point in time.[8,9] Despite the study limitations, this survey has identified some priority areas including efficacy of documentation practices related to care of urinary catheters which are key to preventing CAUTIs. There were also no obvious sources of bias.

Conclusion

To tackle the issue of CAUTIs and other HAIs in Australia, it is imperative to develop a national surveillance system based on validated methods and definitions which have been found to be effective in other developed countries. This study provides a foundation for the development of a national infection control initiative in our rapidly evolving healthcare environment and associated challenges with drug resistance.

Author contribution

All authors contributed to design of study and development of instruments. BM, WB and OF supervised data collection. OF & AG conducted initial data analysis. All authors contributed to further data analysis and manuscript preparation.

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Competing Interests

None.

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Data sharing statement

No additional data available.

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Tables

Table 1. Patient Demographics

Characteristic			Private Hospitals *n*(%) *n* = 204	Public Hospitals *n*(%) *n* = 905	Total (%) *N* = 1109
Age Category (in years)		<35	21 (10.3)	210 (23.2)	231 (20.8)
		35-64	46 (22.5)	292 (32.3)	338 (30.5)
		65-84	82 (40.2)	299 (33.0)	381 (34.4)
		≥85	55 (27.0)	104 (11.5)	159 (14.3)
Gender		Male	79 (38.7)	426 (47.1)	505 (45.5)
		Female	125 (61.3)	479 (52.9)	604 (54.5)
Ward Specialty	Surgery		69 (33.8)	300 (33.1)	369 (33.3)
	General Medicine		55 (27.0)	273 (30.2)	328 (29.6)
	General Practice/Rehabilitation/Geriatric Medicine		37 (18.1)	100 (11.0)	137 (12.4)
	Obstetrics/Gynaecology		17 (8.3)	86 (9.5)	103 (9.3)
	Oncology		17 (8.3)	55 (6.1)	72 (6.5)
	Paediatrics		7 (3.4)	63 (7.0)	70 (6.3)
	High Dependency Unit		0 (0)	28 (3.1)	28 (2.5)
	Other (Pain management)		2 (1.0)	0 (0)	2 (0.2)
DRG*	Diseases of the musculoskeletal system and connective tissue		41 (20.1)	130 (14.4)	171 (15.4)
	Factors influencing health status and other contacts with health services		5 (2.5)	89 (9.8)	94 (8.5)
	Diseases of the digestive system		18 (8.8)	63 (7.0)	81 (7.3)
	Diseases of the circulatory system		8 (3.9)	65 (7.2)	73 (6.6)
	Diseases of the respiratory system		14 (6.9)	47 (5.2)	61 (5.5)
	Pregnancy, childbirth and pueperium		11 (5.4)	47 (5.2)	58 (5.2)
	Diseases of the nervous system		15 (7.4)	39 (4.3)	54 (4.9)
	Newborns and other neonates		16 (7.8)	27 (3.0)	43 (3.9)
	Major procedures where the principal diagnosis may be associated with any Major		16 (7.8)	18 (2.0)	34 (3.1)

	Diagnostic Category			
	Diseases of the kidney and urinary tract	8 (3.9)	25 (2.8)	33 (3.0)
	Other¥	38 (18.6)	133 (14.7)	171 (15.4)
	Missing‡	14 (6.9)	222 (24.5)	236 (21.3)

*DRG = Diagnosis Related Group

¥ = Diseases of the skin, subcutaneous tissue and breast; Injuries, poisoning and toxic effects of drugs; Diseases of the hepatobiliary system and pancreas; Neoplastic Diseases (haematological and solid neoplasms); Infectious and parasitic diseases; Endocrine, nutritional and metabolic diseases and disorders; Diseases of the ear, nose, mouth, and throat; Diseases of the female reproductive system; Diseases of the male reproductive system; Mental diseases and disorders; Diseases of the blood and blood forming organs and immunological diseases; Diseases of the eye; Burns

‡ = Missing DRG data includes all patients in one public hospital

Table 2. Microbial Characteristics for non-CAUTI HAUTIs and CAUTIs

Type of Organism		Non-CAUTI *N* = 5	ICD10 code YES/NO	CAUTI *N* = 10	ICD code YES/NO	TOTAL *N* = 15
Gram positive	*Enterococcus* species	1	no	1	no	2
	Staphylococcus aureus	1	yes	2	1 yes 1 no	3
Gram negative	*Escherichia coli*	0	NA	2	yes	2
	Klebsiella species	0	NA	1	no	1
	Proteus species	2	no	0	NA	2
	Pseudomonas species	1	no	0	NA	1
Fungi	*Candida* species	0	NA	3	1 yes 2 no	3
Organism not listed		0	NA	1	yes	1

NA = Not Applicable

Table 3. Comparison of CDC and HPA Surveillance definitions

	CDC* POSITIVE	CDC NEGATIVE	TOTAL
HPA POSITIVE	11 (1.0%)	1 (0.1%)	12 (1.1%)
HPA NEGATIVE	3 (0.3%)	1094 (98.6)	1097 (98.9%)
TOTAL	14 (1.3%)	1095 (98.7%)	1109 (100.0%)

*NB: For the purposes of calculation, the CDC definition was considered to be gold standard

The percentages represent the number of people identified as having a HAUTI based on a specific criteria divided by the total number of people surveyed.

Table 4. Estimates of the Positive Predictive Value, Sensitivity and Confidence Intervals of the HPA surveillance definition compared to the CDC definition

Result	Value (%)	Confidence Interval
Sensitivity	78.57	(52.41, 92.43)
Specificity	99.91	(99.48, 99.98)
Positive Predictive Value	91.67	(64.61, 98.51)
Negative Predictive Value	99.73	(99.2, 99.91)
Diagnostic Accuracy	99.64	(99.08, 99.86)

Table 5. Catheter Information

Characteristic		Private Hospitals (%) *n* = 60	Public Hospitals (%) *n* = 232	Total (%) *N* = 292
Catheter at any time During this Admission	Yes	60 (29.4)	232 (25.6)	292 (26.3)
	No	144 (70.6)	673 (74.4)	817 (73.7)
Presence of Catheter	Currently insitu	29 (48.3)	146 (62.9)*	175 (59.9)
	Catheter inserted but removed during admission	31 (51.7)	85 (36.7)	116 (39.7)
	Intermittent	0 (0)	1 (0.4)	1 (0.4)
Catheter Location	Indwelling	54 (90.0)	205 (88.4)	259 (88.7)
	Suprapubic	4 (6.6)	10 (4.3)	14 (4.8)
	Intermittent	0 (0)	2 (0.9)	2 (0.7)
	Both indwelling and suprapubic	1 (1.7)	0 (0)	1 (0.3)
	Not documented	1 (1.7)	15 (6.4)	16 (5.5)
Catheter Type	Silver alloy	0 (0)	1 (0.4)	1 (0.3)
	Silicone	7 (11.7)	55 (23.7)	62 (21.2)
	Antimicrobial	0 (0)	0 (0)	0 (0)
	Foley	0 (0)	19 (8.2)	19 (6.5)
	Latex	0 (0)	2 (0.9)	2 (0.7)
	Other	0 (0)	11 (7.8)	11 (3.8)
	Not documented	53 (88.3)	144 (62.1)	197 (67.5)
Catheter Size (French Grade)	6	0 (0)	1 (0.4)	1 (0.3)
	10	0 (0)	1 (0.4)	1 (0.3)
	12	16 (26.7)	16 (6.9)	32 (11.0)
	14	10 (16.7)	54 (23.3)	64 (22.0)
	16	8 (13.3)	19 (8.2)	27 (9.2)
	18	0 (0)	3 (1.3)	3 (1.0)
	20	2 (3.3)	2 (0.9)	4 (1.4)
	22	0 (0)	1 (0.4)	1 (0.3)
	24	1 (1.7)‡	0 (0)	1 (0.3)

	Not documented	24 (40.0)	135 (58.2)	159 (54.5)
Inserted by	Nurse	5 (8.3)	46 (19.8)	51 (17.5)
	Doctor	13 (21.7)	18 (7.8)	31 (10.6)
	Other (student)	1 (1.7)	1 (0.4)	2 (0.7)
	Not documented	41 (68.3)	167 (72.0)	208 (71.2)
Reason for Insertion Stated	Yes	36 (60.0)	77 (33.2)	113 (38.7)
	No	24 (40.0)	155 (66.8)	179 (61.3)
Cleaning Solution	Chlorhexidine	0 (0)	1 (0.4)	1 (0.3)
	Unknown	60 (100)	231 (99.6)	291 (99.7)
Ongoing Need for Catheter Reviewed (days)	0	34 (56.7)	157 (67.7)	191 (65.4)
	1	10 (16.7)	35 (15.1)	45 (15.4)
	2-3	5 (8.3)	24 (10.3)	29 (9.9)
	4-5	1 (1.7)	3 (1.3)	4 (1.4)
	>5	0 (0)	3 (1.3)	3 (1.0)
	Not documented	10 (16.7)	10 (4.3)	20 (6.8)

*It is unknown if catheter still insitu for 3 of these participants at time of survey.

‡1 patient had both indwelling and suprapubic catheters of 2 different sizes.

A Point Prevalence Cross Sectional Study of Health Care Associated Urinary Tract Infections in Six Australian Hospitals

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Abstract

Objectives: Urinary tract infections account for over 30% of healthcare associated infections. The aim of this study was to determine healthcare associated urinary tract infection (HAUTI) and catheter associated urinary tract infection (CAUTI) point prevalence in six Australian hospitals to inform a national point prevalence process and compare two internationally accepted HAUTI definitions. We also described the level and comprehensiveness of clinical record documentation, microbiology laboratory and coding data at identifying HAUTIs and CAUTIs.

Setting: Data were collected from three public and three private Australian hospitals over the first six months of 2013.

Participants: A total of 1109 patients were surveyed. Records of patients of all ages, hospitalised on the day of the point prevalence at the study sites were eligible for inclusion. Outpatients, patients in adult mental health units, patients categorised as maintenance care type (i.e. patients waiting to be transferred to a long term care facility) and those in the emergency department during the duration of the survey were excluded.

Outcome measures: The primary outcome measures were the HAUTI and CAUTI point prevalence.

Results: Overall HAUTI and CAUTI prevalence was 1.4% (15/1109) and 0.9% (10/1109) respectively. *Staphylococcus aureus* and *Candida species* were the most common pathogens. One quarter (26.3%) of patients had a urinary catheter and fewer than half had appropriate documentation. Eight of the 15 patients ascertained to have a HAUTI based on clinical records (six being CAUTI) were coded by the medical records department with an ICD-10 code for UTI diagnosis. The Health protection Agency Surveillance definition had a positive predictive value of 91.67% (confidence interval 64.61-98.51) compared against the Centers for Disease Control and Prevention definition.

Conclusions: These study results provide a foundation for a national Australian point prevalence study and inform the development and implementation of targeted HAI surveillance more broadly.

Strengths and limitations of this study

- This is the first study to compare two internationally accepted definitions in categorising patients with CAUTIs, namely the Health Protection Agency and Centers for Disease Control and Prevention definitions.
- This study demonstrates the feasibility of conducting point prevalence surveys of HAUTIs in a standardised manner to facilitate comparisons over time within individual health facilities.
- A limitation of this study is that the survey was conducted in only six hospitals within two states and territories limiting the generalisability of the results. However, there were significant findings enabling recommendations for a future national point prevalence study to be made.

Background/Rationale

Healthcare associated infections (HAIs) have considerable medical consequences and pose a significant problem for patient safety.[1] A recent systematic review and meta-analysis of 220 international articles indicated that the prevalence and incidence of HAIs is 10% and 7% per 100 patients, respectively.[2] Further, the prevalence of infected patients is 11% per 100 patients.[2] Fifty percent of the reviewed prevalence studies stated magnitudes of infected patients higher than 10% per 100 patients.[2] The Centers for Disease Control and Prevention estimates that 1.7 million people develop HAIs and 100,000 people die of HAI related complications each year in the United States.[3] The first European Union (EU)-wide point prevalence survey (PPS) of healthcare-associated infections and antimicrobial use in hospitals conducted in 2011–2012, estimated that on any given day, about 80 000 patients have at least one HAI, i.e. one in 18 patients in a European hospital has an HAI.[4] The studies support the view that HAIs are the most common complication of hospitalisation. This concept is not new, as demonstrated in a landmark paper "*To Err is Human: Building a Safer Health System*" published in 1999 by the Institute of Medicine (IOM).[5] However, these infections are a potentially preventable adverse event rather than an unpredictable complication and it is possible to significantly reduce the rate of HAIs through effective infection prevention and control.[6]

HAIs could be prevented by sustained, multifaceted infection prevention and control programmes, including the Hawthorne effect of surveillance.[4] Although prospective active surveillance is considered to be the gold standard for surveillance, prevalence surveys are quite useful as they can provide baseline information about the occurrence and distribution of HAI, are generally easy to conduct, relatively inexpensive and not too time-consuming.[7-8] National surveillance of HAI has been introduced in North America and in many European countries and national prevalence surveys of HAI are also increasingly common.[8]

Urinary tract infections account for more than 30% of HAIs reported by acute care hospitals.[9] Virtually all healthcare-associated urinary tract infections (HAUTIs) are caused by instrumentation of the urinary tract with 80% traced to the use of indwelling urinary catheters.[10] The use of urethral catheters is very common with 15% to 25% of hospitalised patients receiving a short-term indwelling urinary catheter hence high HAUTI rates are not surprising.[11-14] Calculation of how many CAUTIs may be preventable varies considerably with estimates from unpublished data ranging from 17% to 69%.[15] Given recommended

infection control measures, up to 380,000 infections and 9000 deaths related to CAUTIs per year could be prevented in the United States.[15]

Unlike other countries, Australia has not recently conducted a national point prevalence study on HAIs. The last Australian national prevalence survey for nosocomial and community-acquired infections was conducted in 1984,[16] with authors reporting a prevalence of 6.3% for HAIs with urinary tract infections contributing to 22% of infections.[16] The most recent study to report the incidence of UTIs in Australia was conducted in two hospitals, with authors reporting an incidence of 1.66%.[17]

To date, in Australia there is no specific national strategy and surveillance system in place to address HAUTIs and CAUTIs.[18-19] Several Australian States undertake surveillance activities for healthcare associated infections including the Victorian Hospital Acquired Surveillance Programme (VICNISS)); South Australian Infection Control Service (SANIT); the Centre for Healthcare Related Infection Surveillance and Prevention (CHRISP) in Queensland;[18, 20] the Tasmanian Infection Prevention and Control Unit (TIPCU) and the Hospital Infection Surveillance program in Western Australia (HISWA). These surveillance programmes differ considerably, with variability in infections surveyed and level of participation by hospitals with no mandatory participation required for hospitals within these states except New South Wales.[21] At present, there is no national or State level surveillance for HAUTIs in Australia hospitals.

To provide the foundation for a national point prevalence study and for a future prospective interventional study, we conducted a preliminary study in 6 Australian hospitals. The aims and objectives of this study were to (1) establish the point prevalence of healthcare associated urinary tract infections (HAUTI) and catheter associated urinary tract infections (CAUTI), (2) describe level and comprehensiveness of documentation related to care of urinary catheters, (3) compare two internationally accepted definitions in categorising patients with CAUTIs, namely the Health Protection Agency (HPA)[22] and Centers for Disease Control and Prevention (CDC)[23] definitions and (4) compare the sensitivity of microbiology laboratory data, coding data and clinical record documentation at identifying cases of HAUTIs and CAUTIs. It is expected that the findings from this study will provide policy makers and healthcare providers in Australia with HAUTI data to inform the development and implementation of targeted surveillance and high-impact HAUTI prevention programs, as well as testing a process for point prevalence of HAUTI.

Methods

Study Design. Cross sectional study

Ethics Approval. Approval for the study was obtained from four health service human research ethics committees and one university committee.

Setting and Data Sources/Measurement. Three publicly funded and three private hospitals in two Australian jurisdictions participated in the point prevalence survey. Two of the three publicly funded hospitals had greater than 400 beds each and similar case mix which included ICU, 24 hour emergency department, Haematology/Oncology units, dialysis units, Paediatrics/Women and Children, Elective and Emergency surgery. The third public hospital had fewer than 400 beds and no paediatric or dialysis services. One private hospital was a rehabilitation hospital and the other two provided acute medical and surgical services.

The survey was conducted over the first six months of 2013 in two phases. The first phase involved two public and two private hospitals and the data were collected concurrently over a single day at these sites. The second phase of the study was conducted in the remaining private and public hospital after additional funding had been obtained. Similar to Phase 1, patient records were concurrently surveyed at both sites.

For each hospital, the survey was conducted using a standardised paper-based questionnaire developed by the researchers from the CAUTI toolkit resources of the CDC ~~Centres for Disease Control and Prevention~~.[24] On the day of the point prevalence study, demographic and clinical data were obtained from patients' notes and laboratory records. Data collected included age, sex, ward speciality, presence of urinary catheter and documentation of insertion, and causative organism where appropriate of all eligible patients. For each patient who had a catheter inserted, documentation was reviewed to determine whether the need for the catheter was assessed daily, consistent with best practice recommendations.[25-26] A separate protocol paper provides more details of the study methods.[27]

The DRG (Diagnosis-related group) and ICD10 (International classification of diseases Tenth revision) coding data were retrieved by the medical records departments approximately two months after completion of the point prevalence survey. Data from the standardised paper based questionnaires were subsequently entered into a purpose designed Excel ™ database and exported into a statistical software package for analysis.

Participants. Records of patients of all ages, hospitalised on the day of the point prevalence at the study sites, were eligible for inclusion, with some exceptions. Outpatients, patients in adult mental health units, patients categorised as maintenance care type (i.e. patients waiting to be transferred to a long term care facility) and those in the emergency department during the duration of the survey were excluded.

Bias. Inter-rater reliability was enhanced by development and use of a standardised training program, with mastery being formally assessed prior to data collection, to reduce the possibility of information bias.[27] The data were collected by trained research assistants who were all registered or enrolled nurses. Before the survey dates, all research assistants were provided with a training package and underwent 2 hours of mandatory face-to-face training and assessment to assist them in collecting point prevalence data and to enhance inter-rater reliability in the application of HAUTI and CAUTI definitions and other survey procedures. The training package and program were developed using the Health Protection Scotland Education and Training Events resources.[28]

Study Size. All hospitalised persons in the participating organisation who met eligibility criteria on a given day were included in the study.

Variables. The main outcome measure was HAUTIs with CAUTI being specifically identified within this outcome. Healthcare associated infection status was defined as hospitalisation greater than 48 hours. Healthcare associated urinary tract infections and CAUTIs were ascertained by using two sets of criteria, those established by the HPA ~~Health Protection Agency~~ / European Centre for Disease Prevention and Control[22] and by the CDC ~~Centers for Disease Control and Prevention~~.[23] These definitions are complex therefore flow diagrams (available as online supplementary material) were provided to research assistants' to assist them with case definitions.[27]

All patients were ascribed one or more diagnosis related codes on discharge from hospital. These codes are known as the Australian Refined DRGs~~Diagnosis Related Groups (AR-DRGs)~~. This classification system enables a hospital's case mix to be described in a clinically meaningful way, enables subsequent use to identify resources required by the hospital, and forms the basis for funding in some Australian States and Territories.[29] Our study collected ICD-10 codes for infection and ICD-10 CM for procedures[30] to identify those relevant to urinary tract infections and catheterisation.

Statistical Methods. Data analysis was performed using IBM Statistics SPSS version 20. Descriptive analysis such as counts and percentages for categorical data and measures of central tendency and dispersion for continuous data was performed. The HAUTI and CAUTI point prevalence were calculated using the total patient population surveyed as the denominator. The sensitivity and positive predictive values of ~~Centers for Disease Control and Prevention (~~CDC~~)~~ and ~~Health Protection Agency (~~HPA~~)~~ surveillance definitions for HAUTI and CAUTI were compared. Cross tabulation and measures of association were applied using Chi-square tests and Fishers Exact test where appropriate to explore differences between public and private hospitals and factors significantly associated with HAUTI and CAUTI.

Results

A total of six hospitals were surveyed over a six month period and all data have been aggregated. Sub-group analysis is limited to public and private hospital status to prevent potential identification of individual participating institutions.

Participants. A total of 1109 patients were surveyed on the designated days. Of these, 505 (45.5%) were male and 604 (54.5%) were female. The median age was 64 years (interquartile range, 42-79 years). Table 1 shows the results stratified by hospital type with 905 patients surveyed from the three public hospitals and 204 from the three private hospitals. The case mix of patients based on the DRG data varied across public and private hospitals with the majority of patients managed for diseases of the musculoskeletal system and connective tissue. This was followed by diseases of the digestive system for the private hospitals and patients assigned codes based on factors influencing health status and other contacts with health services for the public hospitals such as patients attending follow-up visits and organ donors (Table 1).

INSERT TABLE 1

Prevalence of UTI. The overall prevalence of HAUTI was 1.4% (15/1109) and the prevalence of CAUTIs was 0.9 % (10). *Staphylococcus aureus* (20%) and *Candida* species (20%) were the most common pathogens identified among the patients with HAUTIs. Table 2 presents the microbial characteristics of all infections. Of the 1109 patients who were included in the survey, 1.1% met the CDC surveillance criteria for symptomatic UTI and 0.2% met the CDC criteria for asymptomatic UTI. 1.0% of the patients met the

microbiological HPA criteria and 0.2% the non-microbiological HPA criteria. There was one patient who had both Microbiological and Non-Microbiological HPA confirmation of UTI.

Tables 3 and 4 provide the comparison of surveillance definitions, the positive predictive value and sensitivity with the HPA definition classified as the "test" and the CDC definition as the "gold standard".

INSERT TABLES 2, 3 & 4

Pattern of Catheter Usage. One quarter (26.3%) of all surveyed patients had a urinary catheter in place during the audit admission with the majority being indwelling catheters (88.7%). Less than half of patients surveyed had appropriate documentation, such as designation of person inserting catheter (28.8%) and reason for insertion (38.7%) (Table 5). For patients with a catheter who had the reason for insertion stated, the majority of catheters were inserted for peri-operative use for selective surgical procedures (38.9%), acute urinary retention (24.8%), and urinary output monitoring in critically ill patients (22.1%).

Of the 292 patients who had a catheter in during the audit only 7 (2.4%) patients were assigned ICD-10 codes by the medical records department as having a urinary catheter with two (0.7%) coded as having a "bladder catheter" during their admission.

INSERT TABLE 5

ICD-10 Codes. Eighty-six (7.8%) patients were coded by the medical records department as having a UTI. This coding did not take into account whether they were healthcare associated or not. Eight of the 15 patients who were ascertained to have a HAUTI based on the CDC and HPA criteria (with six of these being CAUTI) were also coded by the medical records department with an ICD-10 code for UTI diagnosis.

Discussion

There were four main findings from this study: the point prevalence of HAUTI was comparable to other studies; identification of poor standards of documentation; a suggestion that the CDC surveillance definition identified more patients with HAUTI compared to the HPA; and that clinical coding data grossly underestimates the incidence of HAUTI. Each of these findings will now be explored in more detail.

The 1.4% HAUTI point prevalence and 0.9% CAUTI point prevalence for this study are consistent with previously published reported rates, both nationally[17] and internationally.[31] Whilst this prevalence may seem low, approximately 20-30% of all HAIs are UTIs.[31-32] Extrapolating our data, we estimate that on any given day, there are approximately 1120 Australian inpatients with a HAUTI, assuming 80 000 acute hospital beds in Australia.[33] In addition, a proportion of bacteraemias are associated with UTIs and these have an associated mortality.[34-36] In the era of increasing antimicrobial resistance, particularly in Gram negative organisms, patient outcomes have the potential to worsen demonstrating a growing need for vigilance in infection prevention and HAUTI surveillance.

In this study, documentation relating to catheter insertion and management in all healthcare facilities in the study was poor. There are two main implications that follow from this – evidence based practice and health economics. For evidence based practice, the lack of documentation about who inserted catheter, catheter type and reasons for insertion, would not inspire confidence in patients about the quality of care provided or compliance with evidence based practice. For example, our survey evaluated documentation against national and international practice recommendations such as whether the ongoing need for a catheter is regularly reviewed.[25-26, 9] The biggest risk for urinary tract infection is duration of indwelling urinary catheter.[9] While it is reasonable to assume that the need for the catheter was regularly renewed for some patients and simply not documented, it is also probable that review of the need for catheter was not undertaken for many. Minimising the number of patients with catheters and the duration of catheterisation could significantly reduce the incidence of UTIs and HAIs more generally.[25] We have identified a potential gap in best practice which lends itself to future prospective interventional studies targeting improvements in urinary catheter care. We identified a further issue with poor documentation as less than 10% of urinary catheter usage was identified by ICD 10 coding. This has potential implications for funding, depending on the funding model applied.

In this study, the CDC surveillance definition identified more patients with HAUTI than the HPA definition. The difference in positive predictive value, however, was not statistically significant. Research assistants responsible for data collection overwhelmingly reported that the HPA definition was easier to use. Therefore, whilst the CDC definition is recognised as the gold standard,[37] and HPA in our study had a lower capture rate, use of the HPA definition is still likely to predict 91.7% (Confidence Interval: 64.6-98.5) of infections

diagnosed through use of the CDC definition. Therefore given the much greater ease of use of the HPA definition, we recommend the use of the HPA definition in future point prevalence studies. Any potential issue of underestimating the incidence of HAUTI using the HPA surveillance definition is less important where data are used in a quality improvement framework, as these data can be used to inform and evaluate interventions[38] rather than for diagnostic purposes or for performance management (i.e., trends overtime being most important). Other authors have commented that prospective UTI surveillance is costly and time consuming to conduct[39-40] therefore we explored alternatives to prospective UTI surveillance by comparing our prevalence data with post discharge coding data. Australian coding data does not distinguish between HAI cases and non-HAI cases. This is unlike the US coding data which provides a present on admission (POA) indicator code to inpatients helping to identify hospital acquired infections.[41] In our study ICD coding missed 50% of HAUTIs. If ICD 10 coding are used to determine the incidence of HAUTI, for reporting purposes our study suggests that such a method will grossly underestimate the number of infections, with implications for funding arrangements. This finding has also been found for other infections.[42]

Recommendations for Practice, Policy and Research

To enable the reduction of HAIs related to the genitourinary tract it is important that all health care facilities have appropriate policies and protocols for insertion of either a urethral or supra pubic catheter. It is important that these policies and protocols are evidenced based. However, prior to inserting a catheter the question of whether the patient requires this procedure should be raised. If the decision is made to insert a catheter then consideration should be given to the size of catheter to insert, the reason for the insertion and duration of time that the catheter will be in place to allow timely removal of the catheter. All information relating to the catheter and its care should also be documented in the notes (this could be in the form of a sticker to be easily found in the notes) and on the care plan.

Documentation by medical and nursing staff is important for the day to day infection prevention and control and to alert staff to ensure timely removal of urinary catheters. If a CAUTI is diagnosed then documentation should include: causative organism, what antibiotics have been commenced, and whether the antibiotics are appropriate to treat that microorganism. Other relevant notes are actions taken, such as removal or replacement of the catheter. One potential way of improving compliance with clinical guidelines and

documentation at both the insertion and maintenance phases of catheter care, is the use of a checklist or 'bundle' approach.[43]

To improve health outcomes for patients it is important to continue exploration of ways to identify and reduce HAUTIs and CAUTIs. We have shown it is feasible to conduct prevalence studies across 6 health institutions and funding should be sought for a national point prevalence of UTIs as demonstrated by countries already undertaking this.[4] Analysing national point prevalence data will provide a baseline for intervention studies that test care bundles to reduce HAUTIs and their sequelae.[43]

Currently, it appears that ICD10 coding is not a reliable way of monitoring prevalence of HAUTI, at least in some healthcare facilities. Our findings were consistent with other HAI coding.[42] This potential under-reporting of infections has implications for policy and healthcare reimbursement, although in some US jurisdictions, healthcare facilities are penalised for HAIs rather than being reimbursed.[44-45] We recommend that facilities undertake audits to compare clinical and coding data periodically.

There are some limitations in our study. The survey was conducted in only six hospitals within two states and territories limiting the generalisability of the results. However, there were significant findings enabling recommendations for a future national point prevalence study to be made. Another limitation of our study is the reliance on clinical records and not direct diagnosis. This was overcome by using research assistants with some prior clinical and infection control knowledge, for example registered nurses, for data collection. The research assistants were adequately trained and the outcome of the training was evaluated by post training case study assessments.[27] Such a process also enhanced inter-rater reliability. There were no previous HAUTI and CAUTI rates for comparison within the study sites as they had not collected this type of data before. As earlier stated, the findings can now be used to make recommendations for conducting point prevalence surveys in a standardised manner to facilitate comparisons over time within individual health facilities. The aggregation of data from all participating hospitals for analysis may be a further limitation. The size and scope of services in these hospitals varies and this in turn presents variations in risk. Regardless, the process we employed is common in point prevalence studies, which only capture data at a specific point in time.[8,9] Despite the study limitations, this survey has identified some priority areas including efficacy of documentation practices

related to care of urinary catheters which are key to preventing CAUTIs. There were also no obvious sources of bias.

Conclusion

To tackle the issue of CAUTIs and other HAIs in Australia, it is imperative to develop a national surveillance system based on validated methods and definitions which have been found to be effective in other developed countries. This study provides a foundation for the development of a national infection control initiative in our rapidly evolving healthcare environment and associated challenges with drug resistance.

Author contribution

All authors contributed to design of study and development of instruments. BM, WB and OF supervised data collection. OF & AG conducted initial data analysis. All authors contributed to further data analysis and manuscript preparation.

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Competing Interests

None.

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Data sharing statement

No additional data available.

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Tables

Table 1. Patient Demographics

Characteristic			Private Hospitals *n*(%) *n* = 204	Public Hospitals *n*(%) *n* = 905	Total (%) *N* = 1109
Age Category (in years)		<35	21 (10.3)	210 (23.2)	231 (20.8)
		35-64	46 (22.5)	292 (32.3)	338 (30.5)
		65-84	82 (40.2)	299 (33.0)	381 (34.4)
		≥85	55 (27.0)	104 (11.5)	159 (14.3)
Gender		Male	79 (38.7)	426 (47.1)	505 (45.5)
		Female	125 (61.3)	479 (52.9)	604 (54.5)
Ward Specialty	Surgery		69 (33.8)	300 (33.1)	369 (33.3)
	General Medicine		55 (27.0)	273 (30.2)	328 (29.6)
	General Practice/Rehabilitation/Geriatric Medicine		37 (18.1)	100 (11.0)	137 (12.4)
	Obstetrics/Gynaecology		17 (8.3)	86 (9.5)	103 (9.3)
	Oncology		17 (8.3)	55 (6.1)	72 (6.5)
	Paediatrics		7 (3.4)	63 (7.0)	70 (6.3)
	High Dependency Unit		0 (0)	28 (3.1)	28 (2.5)
	Other (Pain management)		2 (1.0)	0 (0)	2 (0.2)
DRG*	Diseases of the musculoskeletal system and connective tissue		41 (20.1)	130 (14.4)	171 (15.4)
	Factors influencing health status and other contacts with health services		5 (2.5)	89 (9.8)	94 (8.5)
	Diseases of the digestive system		18 (8.8)	63 (7.0)	81 (7.3)
	Diseases of the circulatory system		8 (3.9)	65 (7.2)	73 (6.6)
	Diseases of the respiratory system		14 (6.9)	47 (5.2)	61 (5.5)
	Pregnancy, childbirth and pueperium		11 (5.4)	47 (5.2)	58 (5.2)
	Diseases of the nervous system		15 (7.4)	39 (4.3)	54 (4.9)
	Newborns and other neonates		16 (7.8)	27 (3.0)	43 (3.9)
	Major procedures where the principal diagnosis may be associated with any Major		16 (7.8)	18 (2.0)	34 (3.1)

	Diagnostic Category			
	Diseases of the kidney and urinary tract	8 (3.9)	25 (2.8)	33 (3.0)
	Other¥	38 (18.6)	133 (14.7)	171 (15.4)
	Missing‡	14 (6.9)	222 (24.5)	236 (21.3)

*DRG = Diagnosis Related Group

¥ = Diseases of the skin, subcutaneous tissue and breast; Injuries, poisoning and toxic effects of drugs; Diseases of the hepatobiliary system and pancreas; Neoplastic Diseases (haematological and solid neoplasms); Infectious and parasitic diseases; Endocrine, nutritional and metabolic diseases and disorders; Diseases of the ear, nose, mouth, and throat; Diseases of the female reproductive system; Diseases of the male reproductive system; Mental diseases and disorders; Diseases of the blood and blood forming organs and immunological diseases; Diseases of the eye; Burns

‡ = Missing DRG data includes all patients in one public hospital

Table 2. Microbial Characteristics for non-CAUTI HAUTIs and CAUTIs

Type of Organism		Non-CAUTI *N* = 5	ICD10 code YES/NO	CAUTI *N* = 10	ICD code YES/NO	TOTAL *N* = 15
Gram positive	*Enterococcus* species	1	no	1	no	2
	Staphylococcus aureus	1	yes	2	1 yes 1 no	3
Gram negative	*Escherichia coli*	0	NA	2	yes	2
	Klebsiella species	0	NA	1	no	1
	Proteus species	2	no	0	NA	2
	Pseudomonas species	1	no	0	NA	1
Fungi	*Candida* species	0	NA	3	1 yes 2 no	3
Organism not listed		0	NA	1	yes	1

NA = Not Applicable

Table 3. Comparison of CDC and HPA Surveillance definitions

	CDC* POSITIVE	CDC NEGATIVE	TOTAL
HPA POSITIVE	11 (1.0%)	1 (0.1%)	12 (1.1%)
HPA NEGATIVE	3 (0.3%)	1094 (98.6)	1097 (98.9%)
TOTAL	14 (1.3%)	1095 (98.7%)	1109 (100.0%)

*NB: For the purposes of calculation, the CDC definition was considered to be gold standard

The percentages represent the number of people identified as having a HAUTI based on a specific criteria divided by the total number of people surveyed.

Table 4. Estimates of the Positive Predictive Value, Sensitivity and Confidence Intervals of the HPA surveillance definition compared to the CDC definition

Result	Value (%)	Confidence Interval
Sensitivity	78.57	(52.41, 92.43)
Specificity	99.91	(99.48, 99.98)
Positive Predictive Value	91.67	(64.61, 98.51)
Negative Predictive Value	99.73	(99.2, 99.91)
Diagnostic Accuracy	99.64	(99.08, 99.86)

Table 5. Catheter Information

Characteristic		Private Hospitals (%) *n* = 60	Public Hospitals (%) *n* = 232	Total (%) *N* = 292
Catheter at any time During this Admission	Yes	60 (29.4)	232 (25.6)	292 (26.3)
	No	144 (70.6)	673 (74.4)	817 (73.7)
Presence of Catheter	Currently insitu	29 (48.3)	146 (62.9)*	175 (59.9)
	Catheter inserted but removed during admission	31 (51.7)	85 (36.7)	116 (39.7)
	Intermittent	0 (0)	1 (0.4)	1 (0.4)
Catheter Location	Indwelling	54 (90.0)	205 (88.4)	259 (88.7)
	Suprapubic	4 (6.6)	10 (4.3)	14 (4.8)
	Intermittent	0 (0)	2 (0.9)	2 (0.7)
	Both indwelling and suprapubic	1 (1.7)	0 (0)	1 (0.3)
	Not documented	1 (1.7)	15 (6.4)	16 (5.5)
Catheter Type	Silver alloy	0 (0)	1 (0.4)	1 (0.3)
	Silicone	7 (11.7)	55 (23.7)	62 (21.2)
	Antimicrobial	0 (0)	0 (0)	0 (0)
	Foley	0 (0)	19 (8.2)	19 (6.5)
	Latex	0 (0)	2 (0.9)	2 (0.7)
	Other	0 (0)	11 (7.8)	11 (3.8)
	Not documented	53 (88.3)	144 (62.1)	197 (67.5)
Catheter Size (French Grade)	6	0 (0)	1 (0.4)	1 (0.3)
	10	0 (0)	1 (0.4)	1 (0.3)
	12	16 (26.7)	16 (6.9)	32 (11.0)
	14	10 (16.7)	54 (23.3)	64 (22.0)
	16	8 (13.3)	19 (8.2)	27 (9.2)
	18	0 (0)	3 (1.3)	3 (1.0)
	20	2 (3.3)	2 (0.9)	4 (1.4)
	22	0 (0)	1 (0.4)	1 (0.3)
	24	1 (1.7)‡	0 (0)	1 (0.3)

	Not documented	24 (40.0)	135 (58.2)	159 (54.5)
Inserted by	Nurse	5 (8.3)	46 (19.8)	51 (17.5)
	Doctor	13 (21.7)	18 (7.8)	31 (10.6)
	Other (student)	1 (1.7)	1 (0.4)	2 (0.7)
	Not documented	41 (68.3)	167 (72.0)	208 (71.2)
Reason for Insertion Stated	Yes	36 (60.0)	77 (33.2)	113 (38.7)
	No	24 (40.0)	155 (66.8)	179 (61.3)
Cleaning Solution	Chlorhexidine	0 (0)	1 (0.4)	1 (0.3)
	Unknown	60 (100)	231 (99.6)	291 (99.7)
Ongoing Need for Catheter Reviewed (days)	0	34 (56.7)	157 (67.7)	191 (65.4)
	1	10 (16.7)	35 (15.1)	45 (15.4)
	2-3	5 (8.3)	24 (10.3)	29 (9.9)
	4-5	1 (1.7)	3 (1.3)	4 (1.4)
	>5	0 (0)	3 (1.3)	3 (1.0)
	Not documented	10 (16.7)	10 (4.3)	20 (6.8)

*It is unknown if catheter still insitu for 3 of these participants at time of survey.

‡1 patient had both indwelling and suprapubic catheters of 2 different sizes.

Health Protection Agency and Centers for Disease Control and Prevention definitions for Urinary Tract Infection

HPA definitions*

Healthcare associated if onset:

- Day 3 of admission onwards (>48 hours) or
- Day 1 or Day 2 AND patient discharged from hospital in preceding 48 hours
- Day 1 or day 2 AND patient has relevant device inserted on this admission prior to onset

CAUTI

If indwelling catheter insitu at time of infection onset or removed in previous >48 prior to symptom onset

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Microbiologically confirmed symptomatic UTI

- Patient has at least one of the following signs of symptoms with no other recognized cause: fever (>38°C), urgency, frequency, dysuria, or suprapubic tenderness

and

- Patient has a positive urine culture, that is, ≥ 10^5 microorganisms per ml of urine with no more than 2 species of microorganisms.

Not microbiologically confirmed symptomatic UTI

- Patient has at least two of the following with no other recognized cause: fever (>38°C), urgency, frequency, dysuria, or suprapubic tenderness

and
at **least one** of the following:

- Positive dipstick for leukocyte esterase and/or nitrate
- Pyuria urine specimen with ≥10 WBC/ml or ≥ 3 WBC/high-power field of unspun urine
- Organisms seen on Gram stain of unspun urine
- At least two urine cultures with repeated isolation of the same uropathogen (gram-negative bacteria or *S. saprophyticus*) with ≥ 10^2 colonies/ml urine in nonvoided specimens
- ≤10^5 colonies/ml of a single uropathogen (gram-negative bacteria or *S. saprophyticus*) in A patient being treated with effective antimicrobial agent for a urinary infection
- Physician diagnosis of a urinary tract infection
- Physician institutes appropriate therapy for a urinary infection

*NOTE: bloodstream infections secondary to asymptomatic bacteriuria are not included

Source: Health Protection Agency. Fourth National Point Prevalence Survey on Healthcare Associated Infections and First National Point Prevalence Survey on Antimicrobial Use and Quality Indicators in England 2011.

CDC definitions

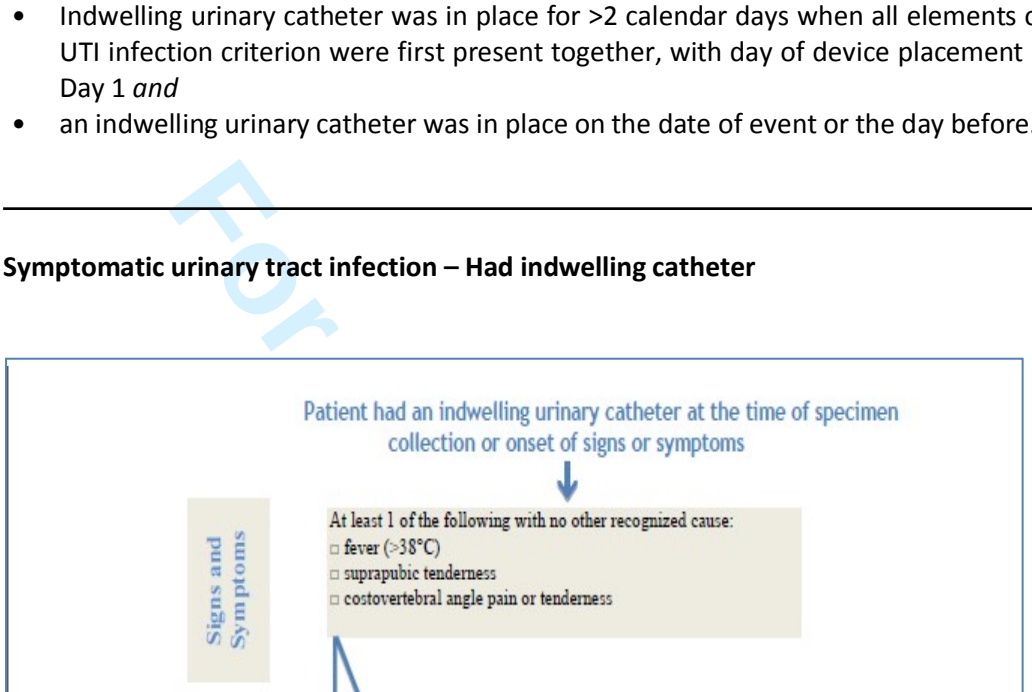
Healthcare associated if onset:

- after the 3rd hospital day (day of hospital admission is day 1) (>48 hours)

CAUTI

- Indwelling urinary catheter was in place for >2 calendar days when all elements of the UTI infection criterion were first present together, with day of device placement being Day 1 *and*
- an indwelling urinary catheter was in place on the date of event or the day before.

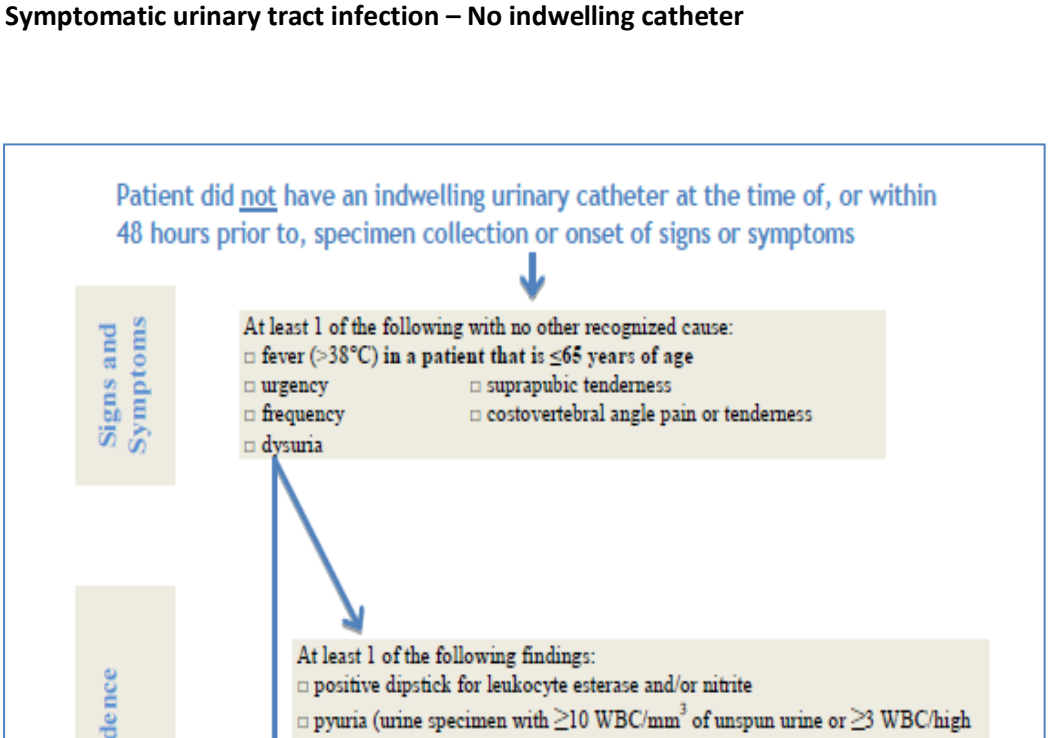
Symptomatic urinary tract infection – Had indwelling catheter



Source: Centres for Disease Control and Prevention. NHSN Patient Safety Component Manual 2012.

CDC definitions

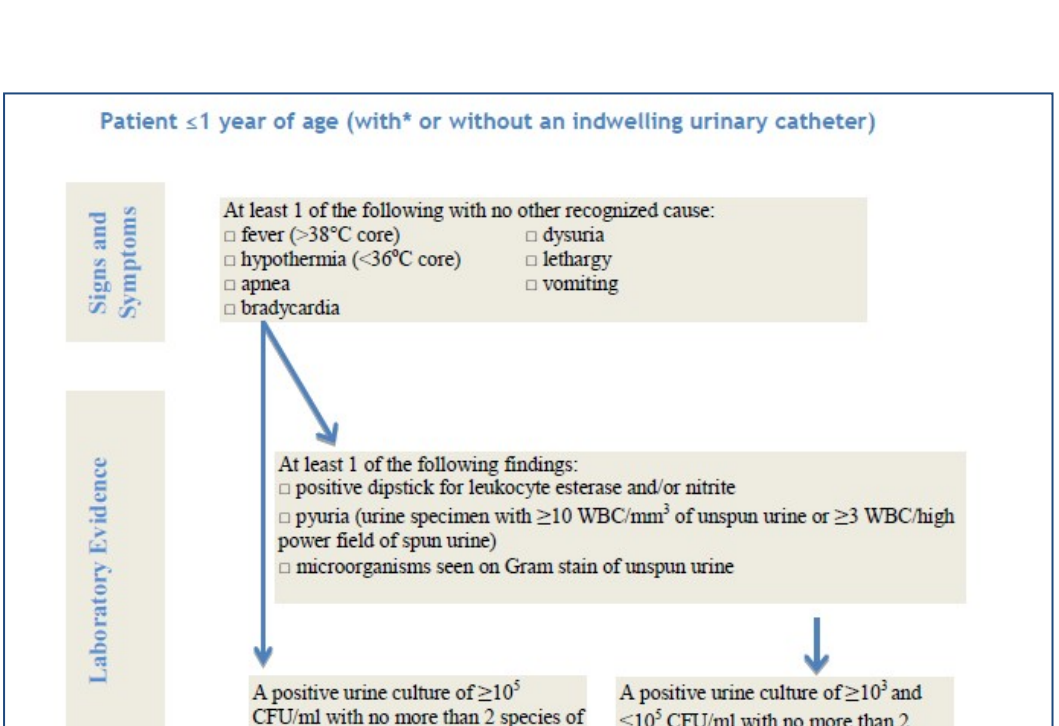
Symptomatic urinary tract infection – No indwelling catheter



Source: Centres for Disease Control and Prevention. NHSN Patient Safety Component Manual 2012.

CDC definitions

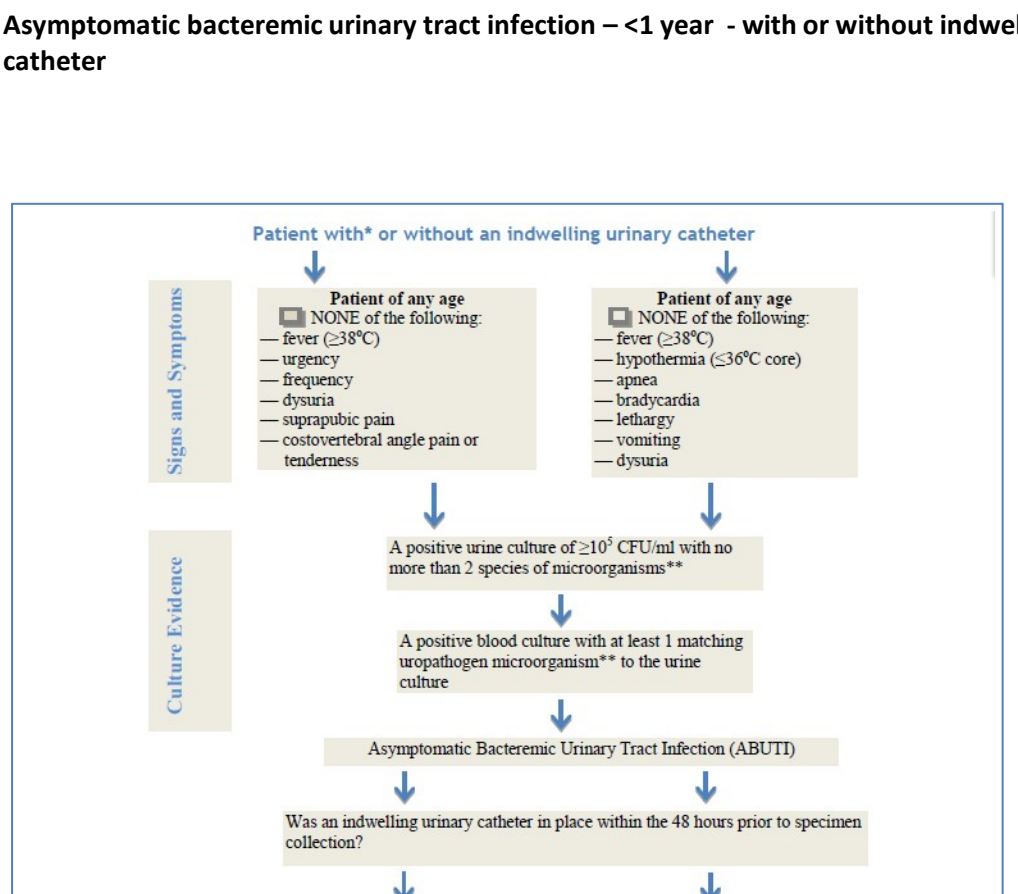
Symptomatic urinary tract infection – <1 year - with or without indwelling catheter



Source: Centres for Disease Control and Prevention. NHSN Patient Safety Component Manual 2012.

CDC definitions

Asymptomatic bacteremic urinary tract infection – <1 year - with or without indwelling catheter



Source: Centres for Disease Control and Prevention. NHSN Patient Safety Component Manual 2012.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract✓
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found✓
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported✓
Objectives	3	State specific objectives, including any prespecified hypotheses✓
Methods		
Study design	4	Present key elements of study design early in the paper✓
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection✓
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants✓
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable✓
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group✓
Bias	9	Describe any efforts to address potential sources of bias✓
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why✓
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding✓
		(*b*) Describe any methods used to examine subgroups and interactions✓
		(*c*) Explain how missing data were addressed✓
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy Not Applicable
		(*e*) Describe any sensitivity analyses✓

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Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders✓
		(b) Indicate number of participants with missing data for each variable of interest✓
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures✓
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized✓
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period Not Applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses✓
Discussion		
Key results	18	Summarise key results with reference to study objectives✓
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias✓
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence✓
Generalisability	21	Discuss the generalisability (external validity) of the study results✓
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based✓

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.