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Abstract

Background and Importance: Urinary tract infections (UTIs) are a leading cause of preventable, hospital-acquired infections (HAIs) in acute care hospitals in the United States and a major public health issue. This analysis aims to characterize the urinary tract infections (UTI) that occurred in all patients of Shirley Ryan AbilityLab (SRAlab), an acute inpatient rehabilitation hospital in Chicago, with the goal of identifying future intervention targets to reduce UTI incidence and reduce the phenomenon of urine over-culturing. The results of this analysis will be used to design UTI-prevention interventions directed toward caregivers and patients, and strategies to prevent over-culturing and maximize resources, improving patient outcomes.

Methods: All hospital-acquired infections (HAIs) between April 1, 2017 and December 31, 2018 were categorized by physiological type of infection, and the total proportion of UTIs was compared to the proportion of all other types of HAI. The percentage of positive HA UTIs that occurred were compared to the number of urine cultures collected to determine if over-culturing had occurred. UTIs were stratified by exposure to two types of urinary catheter, foley or intermittent catheter (CAUTIs or ICPs, respectively), or no exposure (no device UTIs), indicating no device was used. Infection rates and prevalence of all UTIs, foley or intermittent catheter, and UTIs that occurred with no exposure to a catheter device were calculated. The relative risk of developing a UTI upon the two types of catheter exposure was calculated compared to the risk of developing a UTI without this exposure. The odds ratio of developing a UTI upon no device exposure was calculated compared to device exposure. To control for differing populations of patients on each floor of SRAlab, all descriptive epidemiological parameters were calculated facility-wide as well as separately for each floor of the hospital

Results: Data analysis showed a high overall proportion of HA-UTIs at SRAlab compared to total HAIs, with HA-UTIs comprising 74% of total HAIs. Over-culturing is present at SRAlab, as only 30% of total urine cultures were HA-UTIs. The burden of no device UTIs and ICPs is high at SRAlab, comprising 40% and 27% of total HAIs, respectively, compared to 6% for CAUTIs. Prevalence varied for CAUTIs, ICPs, and no device UTIs facility-wide and prevalence varied within floors of the hospital. Infection rates varied by floor of the hospital for CAUTIs, ICPs, and no device UTis. Despite the high burden of no device UTIs at SRAlab, the relative risk of experiencing UTI was still highest upon any device exposure (foley catheter or intermittent catheter) compared to no device exposure. Intermittent catheter exposure presented a higher relative risk of UTI occurrence compared to foley catheter exposure.

Conclusions: Focusing on infection prevention interventions targeting UTIs at SRAlab is justified given the high overall proportion of HA-UTIs and prevalence of UTIs. Over-culturing represents a potential area of intervention at SRAlab. When designing interventions, it is important to analyze data separately for individual floors of acute care facilities with different patient demographics by floor. When assessing HA-UTIs, it is important to stratify by catheter device exposure, as different floors experience different burdens of infection by device type. No device-associated UTIs and intermittent catheter-associated UTIs represent significant areas for potential intervention at SRAlab, despite the public health literature’s focus on CAUTIs.

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Background and Statement of Public Health Relevance

Healthcare-associated infections (HAIs) are a preventable major public health issue resulting in significant healthcare costs and affecting the quality of life of infected individuals. In the United States, HAIs occur in the average range of 4.5 infections per 100 admissions, resulting in approximately 1.7 million infections annually(1). The high occurrence of HAIs results in significant mortality and morbidity, making HAIs a substantial cause of death in the United States. In addition to undesirable patient outcomes, HAIs represent a major healthcare cost due to additional treatment and extended hospitalizations. Depending on the type of HAI, the cost of treatment per case can range from $1000-$45,000(2) resulting in 5-10 billion dollars in annual healthcare costs(1). From both the perspective of improving patient care directly through decreasing mortality and morbidity, as well as improving patient care indirectly through decreased healthcare costs, designing interventions to prevent HAIs is an important focus of public health agencies, healthcare workers, infection preventionists, and healthcare administers.

HAIs are considered preventable infections because actions on the part of healthcare providers and clinicians have been proven to greatly reduce the incidence of HAIs. Specific actions that have been shown to reduce the burden of HAIs in acute care settings include the proper usage of healthcare antiseptics, like handwashing compliance by healthcare providers, use of surgical scrubs by surgeons, and the use of antiseptic skin preparations on the patient before surgery or an invasive device procedure(2). Hand hygiene programs are an indispensable component of HAI prevention, and include educating healthcare providers and patients, compliance assessments, as well as structural necessities like properly placed antiseptic dispensers and sinks within hospitals(3). In addition, it is important that clinicians comply with proper sterile technique during invasive or surgical procedures, and it is important to maintain a hospital free of environmental reservoirs for infectious organisms. Patient education on handwashing hygiene, post-procedural maintenance of wounds, and proper maintenance of devices are also necessary to prevent HAIs. Despite these known effective intervention strategies, HAIs are multifaceted cases comprised of myriad causative organisms, environmental factors, and individual health risks. Due to this complexity, proper cost-effective interventions are often uncertain. In order to assess the best HAI intervention strategy for a specific healthcare facility, it is important to consider the patient population and environmental concerns specific to that facility.

Currently, the Centers for Disease Control and Prevention (CDC) estimates that 1 in every 31 patients acquires an infection, with the five most common types of HAIs accounting for 9.8 billion dollars in healthcare costs annually in the United States (4). HAIs occur most regularly when a patient has been exposed to an invasive medical device procedure or a surgical procedure(1). The five most common types of HAIs that require additional measures of care and prevention are catheter-associated urinary tract infections (CAUTIs), central-line associated bloodstream infections, *Clostridium difficile* infections of the gastrointestinal tract, ventilator-associated pneumonia, and infections at the site of surgery(5). Central-line associated infections (CLABSIs) occur in the bloodstream when an infectious organism gains access directly to the blood through the insertion of a central line catheter for efficient, regular drug delivery to the bloodstream. Surgical site infections (SSIs), or wound infections, occur commonly following a surgical procedure, despite modern advances in infection prevention. Ventilator-associated pneumonia occurs in patients who require assistance breathing following endotracheal intubation when the site of insertion is rendered susceptible to infectious organisms or a contaminated device introduces organisms into the lungs. *Clostridium difficile* infections require multifaceted diagnosis using stool, and often occur in patients who've already taken courses of antibiotics. Other factors that may contribute to patients developing an HAI include healthcare workers transferring infectious organisms to patients, as well as subsets of patients being susceptible to infection due to compromised immune responses or infectious organism exposure to an open wound or site of an invasive medical device. It is estimated that 12-17 microorganisms cause over 80% of all HAIs, with many of the most commonly occurring organisms being gram-negative bacteria(6).

Urinary tract infections (UTIs), the focus of this study, comprise approximately 40% of all HAIs (6-8) and are the most common HAI reported to the National Healthcare Safety Network (https://www.cdc.gov/hai/ca_uti/uti.html). Clinically, a UTI occurs when a microbial organism enters the urinary tract system and grows to a density of more than 10^5 colonies/mL in the urine(7). UTIs can be caused by Gram-negative and Gram-positive bacteria as well as fungi, but the most common causative agents of HAIs are *Escherichia coli, Klebsiella pneumoniae, Proteus mirabilis, Enterococcus faecalis and Staphylococcus saprophyticus.* Of these organisms, uropathogenic *Escherichia coli* (UPEC), is the most common causative agent of HA-UTIs(9). During a UTI, a uropathogen first adheres to the cells lining the urogenital tract, then establishes colonization of this anatomical niche before ascending to colonize the bladder. In the bladder, the colonizing organisms can form a biofilm, or a multicellular microbial community living within an adhesive scaffold. Biofilms are harder to clear from the body, less responsive to antibiotics, and can result in recurring and persistent infections(9). Clinical symptoms of UTI can include bladder pain with urination, bladder urgency, increase in the frequency of urination, fever, suprapubic pain tenderness and costovertebral angle pain or tenderness (https://www.cdc.gov/hai/ca_uti/uti.html). For these reasons, UTI diagnosis is confirmed upon testing of a patient's urine culture for causative organisms and with consideration of clinical symptoms described above(10).

HA-UTIs and community-associated UTIs are treated with antibiotics, and due to the sheer magnitude of the UTI burden worldwide, strains with multi-drug resistance are on the rise (7, 9). These antibiotic treatments permanently alter the composition of the resident symbiotic microflora within a patient's urogenital tract and gastrointestinal tract, and should thus only be prescribed when necessary, to clear an infection. In addition, populations of microorganisms naturally evolve genes that encode for resistance to antibiotics to which they are exposed, leading to growing populations of antibiotic resistant organisms. Antibiotic resistance itself is a major public health concern, and preventing infections can decrease the amount of antibiotics prescribed, as well as the persistence of antibiotic resistant organisms within a healthcare setting. A study in rural nursing home patients showed that antimicrobial stewardship efforts to avoid over-culturing for UTIs and over-prescription of antibiotics were effective in this setting (11). Antibiotic stewardship programs in acute care settings help monitor and analyze whether patients are prescribed the appropriate antibiotics for the appropriate length of time at the appropriate dosage, all directed toward patient safety and curtailing rising antibiotic resistance. Assessment of whether over-culturing of urine in SRAlab patients has occurred in this study will help to identity if interventions to curtail over-culturing and unnecessary antibiotic prescriptions may be necessary at SRAlab.

General risk factors for UTI include female gender, age, prior UTI, and use of a urinary catheter device (9). According to the CDC, approximately 75% of HA-UTIs are associated with a urinary catheter, or device inserted into the bladder through the urethra to drain urine (https://www.cdc.gov/hai/ca_uti/uti.html). An indwelling, foley catheter, hereon referred to as a foley catheter, is a tube inserted into the bladder through the urethra and an essential healthcare tool for managing patient voiding when patients are not able to void on their own, or when a patient's condition necessitates an alternative voiding mechanism(12). An estimated 15-25% of patients require a catheter device to assist in voiding of urine during a hospital stay (8). Taken together, these circumstances render catheter utilization a significant risk factor for HA-UTI that affects a significant portion of hospital patients. However, these statistics are specific to foley catheters, and do not include the risk of UTI associated with the use of a different type of alternative voiding devices called intermittent catheters.

Because a foley catheter remains in the urethra, insertion is a sterile process. In contrast, another type of catheter, called an intermittent catheter, is inserted and removed several times a day in a clean, but not formally sterile insertion procedure. Both types of catheter usage are associated with increased risk of HA-UTI, with a recent study citing foley catheter usage resulting in a 10-fold increase in HA-UTI risk, and intermittent catheter usage resulting in a 4-fold increase in HA-UTI risk for patients with neurogenic bladder disease(5). As detailed below, patients at the Shirley Ryan AbilityLab (SRAlab) are often recovering from surgery and/or spinal cord injury, thus this patient population is likely to experience increased incidence of neurogenic bladder disease, which often requires long-term management with an intermittent catheter program. An analysis determining specific risk factors within this population could prevent HA-UTIs.

Overall, this study aims to analyze trends in UTIs among the inpatient population at SRAlab to identify the best possible targets for intervention. Long term, this project should aid in reducing overall UTI incidence and improving patient outcomes through reduced disease burden and reduced burden of disease complications. As the inpatient population at SRAlab is undergoing physical therapy, patients normally have a length of stay that is longer than acute care hospitals that are not rehabilitation facilities. Results from the patient population at SRAlab may be applicable to other rehabilitation hospitals with an average patient length of stay ranging from two weeks to over a year. In addition, the results may apply to other long term care facilities, such as facilities that provide skilled nursing facilities, long term acute care facilities or facilities that provide end of life care.

Statement of Oversight

When a urinary infection occurs within the SRAlab, data regarding relevant patient information is collected and analyzed, including date of admission, date of symptoms onset, treatment, location of the patient within the hospital, and any confounding data regarding secondary infections. Public health agencies require surveillance and reporting of these hospital-acquired infections. This study was conducted using previously collected surveillance data between April 1, 2017 and December 31, 2018 by SRAlab for quality control and process improvement initiatives related to patient care with authority and oversight from the Infection Control Committee, Patient Safety and Hospital Accreditation and the Department of Physical Medicine and Rehabilitation. All institutional, city and federal guidelines regarding patient privacy and HIPAA compliance were observed during this analysis.

Methods

Patient Population

The Shirley Ryan AbilityLab is an inpatient rehabilitation facility with 240 inpatient beds. While SRAlab has satellite outpatient facilities in the city of Chicago, patient data from these facilities were not included in the analysis, as the study is focused on preventing HA-UTIs using inpatient data from the main hospital and characterization of infection prevention issues by hospital floor, data from inpatients admitted to floors 18 through 25 of the main hospital were included in this study. As patients being treated in an outpatient facility have a length of stay less than 2 days, the criteria this study used to define a hospital-acquired infection, data from these patients were not relevant to the study. Patients at SRAlab include traumatic and non-traumatic brain injury, traumatic and non-traumatic spinal cord injury, stroke, neurology, cancer, transplant, general orthopedic, amputation, and medically complex patients with acute or chronic comorbidities.

Source Data

Shirley Ryan AbilityLab patient database was scanned for laboratory cultures taken between April 1, 2017 and December 31, 2018. Cultures taken from outpatient facilities were excluded, as well as duplicate cultures taken from the same patient on the same day. Cultures taken from the same patient on different days were counted separately. Viral serology cultures were excluded from the analysis, as they are indicative of immunity or past exposure rather than acute infection, and did not meet the criteria for hospital-acquired symptomatic infections. This dataset provided the basis for the number of cultures collected from disparate anatomical sites, separated into blood, respiratory, wound, stool, and urine cultures. The number of cultures that yielded positive laboratory results alongside associated clinical symptoms of infection were considered true infections and coded and reported as hospital-acquired symptomatic infections for blood, respiratory, wound, stool, and urine cultures. Cultures that gave positive lab results in the absence of clinical symptoms were considered colonizations rather than true, symptomatic infections, and were excluded from inclusion in this analysis. If a culture came back positive for more than one organism, it was counted as one infection. Symptomatic hospital-acquired infections excluded any cultures that had been collected prior to the patient’s third day of admission, as those were considered present upon admission. Upon stratification by type of UTI, UTIs occurring in patients with a foley catheter were coded as catheter-associated urinary tract infections, or CAUTIs, UTIs occurring in patients with an intermittent catheter were coded as intermittent catheter present urinary tract infections, or ICPs, and UTIs occurring in patients with no exposure to a catheter device were coded as no device UTIs.

Data Analysis

In order to report descriptive statistics, the total number of true urine infections were counted and compared to the total number of infections from all other categorized anatomical sites, and divided by the patient population for total incidence of total UTIs. The percentage of hospital-acquired infections compared to all cultures collected was calculated to ascertain whether over-culturing, or taking many more cultures for analysis than contain true hospital-acquired symptomatic infections, was occurring. UTIs were then stratified by hospital unit and by type of UTI: CAUTIs, ICPs, and no device UTIs. Patient days, foley-catheter device days, and intermittent catheter device days were counted for use as denominators when calculating the infection rates of CAUTI, ICP, and no device UTI both facility-wide and for each floor, respectively.

Infection rates were calculated by dividing the number of infections of each type by 1000 device days or patient days for each floor. Denominator for CAUTI infection rate was 1000 foley device days; ICP infection rate denominator was 1000 intermittent catheter device days, and no device UTI infection rate denominator was 1000 patient days. Prevalence was calculated by dividing the number of infections of each type by the admissions for that floor within the time period for analysis. Relative risk and odds ratios were calculated for each type of UTI (CAUTI, ICP, and Any Device) using the following calculations:

	UTI	Yes	No
Device (CAUTI, ICP or Any Device)	Yes	A	B
	No	C	D

Relative risk = RR = (A/A+B)/(C/C+D).

Odds ratio = OR = (A*D) / (B*C)

Odds ratio for no device = 1/OR for Any Device

Relative risks were calculated to ascertain the risk of a UTI occurring upon foley catheter exposure compared to all other types of UTI, the risk of a UTI occurring upon intermittent catheter device exposure compared to all other types of UTI, and the risk of any device (foley and intermittent catheter combined) compared to no device UTI. As it was not mathematically possible to calculate the relative risk of no device exposure compared to any device exposure for this data set, the corresponding odds ratios were calculated. As patients with no device UTIs did not have a device exposure, we calculated the odds of experiencing a UTI with no device present compared to the presence of any device.

Limitations

In order to design interventions to improve patient outcomes with respect to infection prevention, it is useful to stratify prevalence and infection rate data by floor. This way, floors with high burdens of infections can be identified and targeted, controlling for differing patient populations admitted to the hospital on each floor by prevalence, and different amounts of device utilization (device days and patient days) on each floor by infection rates. This study did not address any differences in patient population besides exposure to a catheter device or location of the patient by hospital floor. Specific differences in patient age, gender, previous exposure to UTI, or immune compromised state were not controlled for in this study, and could limit the applicability of results outside SRAlab. In addition, due to the public health literature focus on CAUTIs, there are a lack of external benchmarks to compare to the ICP and no device UTI prevalence values in this study. CAUTI prevalence was relatively low in the SRAlab population, due to low device utilization and possibly high prevention performance of patients and healthcare staff.

Results

Facility-Wide Trends in UTI Proportion and HAI Descriptive Statistics

The analyses yielded a set of summary statistics for the patient population represented in **Table 1.** Out of the 1974 total cultures of all types collected, 512 of these represented hospital-acquired symptomatic infections. The criteria for categorizing a UTI as symptomatic and hospital-acquired removed a significant number of cultures from the total number of cultures collected. A total of 1407 urine culture were collected, but only 378 of these cultures represented symptomatic and hospital-acquired infections. Therefore, only 30% of the urine cultures collected were hospital-acquired symptomatic infections. The other 70% of urine cultures collected represent asymptomatic bladder colonization. Of the 512 hospital-acquired symptomatic infections of all types, 378 were UTIs. Therefore, 73.8% of all hospital-acquired infections were urinary tract infections.

Facility-Wide UTI proportion by UTI Type

The data for all 378 hospital-acquired symptomatic urinary tract infections were stratified by the type of urinary tract infection to ascertain the respective infectious burden of CAUTIs, ICPs, and no device-associated UTIs, as represented in **Table 2**. Of the 378 total hospital-acquired symptomatic UTIs, 31 were CAUTIs, 140 were ICPs, and 207 were no device UTIs. No device UTIs represent the highest proportion of all types of UTIs, comprising 55% of UTIs. CAUTIs and ICPs represented the other 8% and 37%, respectively. As UTIs comprised 73.8% of the total HAIs of all types, when these data are stratified by type of UTI, as illustrated in **Figure 1,** no device UTIs comprise 40.4% of total HAIs of all types, ICPs comprise 27.3% of total HAIs of all types, and CAUTIs comprise 6.0% of total HAIs of all types. All the other types of HAI at SRAlab make up just 26.2% of total HAIs compared to 73.8% HA-UTIs.

Facility-Wide Prevalence by UTI Type

Facility-wide UTI prevalence was calculated in order to characterize UTI trends in SRAlab, as well as compare to other prevalence values in the public health literature. Facility-wide UTI prevalence by type of UTI (CAUTI, ICP, and no device) was calculated by dividing the number of each type of UTI by the number of admissions to SRAlab within the time period of this study (**Figure 2).** The average prevalence of all types of HAIs given by the literature is 4.5 infections per 100 admissions, or 0.045(1). Different UTI types gave differing results for prevalence, with no device UTIs giving high prevalence overall, nearly 0.038. ICP prevalence facility-wide was 0.025, and CAUTI prevalence was lowest at 0.005. In order to see if facility-wide prevalence represented consistent values between floors, or if different floors varied, the prevalence values for each floor, 18-25, was calculated.

Prevalence of UTI Types by Hospital Location

To standard for different amounts of admissions across different SRAlab floors, prevalence by floor was calculated. No device prevalence ranged, on most floors, between 30-50 infections per 1000 admissions, or 0.03-0.05. ICPs gave varying prevalence values across floors, with some floors ranging very low, below 10 infections per 1000 admissions, and some floors giving the highest prevalence values, nearing 80 infections per 1000 admissions, or 0.08. CAUTI prevalence was low in general, between 0.0-0.2. As prevalence calculations allowed for comparisons to the literature and comparisons between UTI device type, this calculation did not control for differences in device utilization between patients.

UTI Infection Rates by Type of UTI by Hospital Location

The CDC estimates that 15-25% of acute care patients require a foley catheter during hospitalization, but it would be incorrect to assume that catheter usage is equally distributed throughout the units of a hospital. In order to control for different amounts of device utilization and time spent on each unit by floor, infection rates were calculated for patients exposed to a foley catheter, intermittent catheter, or no exposure to a device by floor **(Figure 3)**. CAUTI infection rates were very low for floors 18 and 23, and similar, nearing 3 infections per 1000 foley catheter days, for floors 19-22, 24-25. ICP infection rates were highest on floors 18 and 20, with values just over 10 infections per 1000 intermittent catheter days. UTIs that were not associated with a device were highest on floor 23, at 2.5 infections per 1000 patient days. Infection rates for different UTI types cannot be compared to one another because the denominators are different, but infection rates allow for comparison of infection rate between different floors of the hospital for each UTI type. Floors with the highest rates of infection within stratified types of UTI represent floors with the highest potential for intervention.

Relative Risk of Experiencing a UTI Upon Types of Device Exposure

The prevalence calculations showed a high burden of no device UTIs at SRAlab, as well as a high burden of ICPs on certain floors. The infection rate calculations allowed for targeting the floors with the greatest rates, controlling for device utilization. These values, however, are not able to compare whether patients are at greater risk of developing a UTI upon foley catheter exposure, which is the focus of much public health literature. In order to compare the relative risk of acquiring a UTI using either type of catheter device, foley or intermittent, compared to a population that was not exposed, relative risk was calculated **(Table 4).** Notably, despite substantially high number of no device UTIs in the SRAlab, the relative risk of acquiring an infection with intermittent catheter exposure ICP was 3.03 facility wide compared to any other type of UTI. In addition, the risk of using any device (CAUTI and ICP) was 1.81 compared to any other type of UTI. The relative risk of infection when exposed to an intermittent catheter was particularly high on floors 18 and 20, with relative risks of 18.76 and 4.38, respectively. In contrast to the literature, many of the relative risk values for CAUTI were below 1, indicating the possibility of protection, further discussed below.

Odds of Acquiring a UTI without Device Exposure

In order to ascertain the odds of developing a UTI without device exposure compared to the population of patients using a device, the odds ratio for no device usage was calculated (**Table 5)**. Despite the high number of no device UTIs, the odds ratio of acquiring a UTI with no device compared to any device was low overall, 0.53.

On floor 23, however, there may be an issue with increased risk of UTI when not using a device, with an odds ratio of 1.79.

Conclusions and Discussion

The results of **Table 1** justify the focus of this study on urinary tract infections, as the total number of urinary tract infections comprises the majority of hospital-acquired symptomatic infections discovered within the patient population, with a proportion of 74% of infections (**Table 1 and Figure 1).** Patients in an acute rehabilitation hospital would uniquely benefit from infection prevention interventions targeting urinary tract infections. Patients at SRAlab undergo physical therapy, based on individual patient needs, to increase mobility and self-sufficiency, as well as heal from surgery or injury.

The small percentage of total hospital-acquired symptomatic urinary tract infections compared to the total number of urine cultures collected, 30%, indicates that over-culturing is occurring in the SRAlab with regard to urine cultures, and represents an area for process improvement. Interventions designed to help healthcare providers better ascertain when to culture a patient's urine at SRAlab would be useful to avoid over-culturing detected in this study. While a certain amount of over-culturing in a healthcare setting is necessary to avoid missing infections and preventing diagnosis, the amount of cultures that were not true hospital-acquired symptomatic infections (70%) indicates a significant opportunity to reduce over-culturing and efficiently use culturing and laboratory resources. The data indicating a high percentage of the

SRAlab's hospital-acquired infections are urinary tract infections is in agreement with the CDC's reported incidence of UTIs in a hospital setting.

The most surprising and novel result of this study was the high no device UTI burden and high overall prevalence of no device UTIs are SRAlab. No device UTis comprised the highest proportion of UTIs facility-wide (**Table 2 and Figure 1).** In additional, a high facility-wide prevalence of ICPs and 18th and 20th floor ICPs was reported. The public health literature focuses on the high risk of HA-UTI upon foley catheter utilization, but, in this patient population, no device UTIs and ICPs represent significant areas with potential for infection prevention. This study indicates the need to expand UTI prevention focus to include UTIs not associated with a device and UTIs associated with intermittent catheter use within specific populations, as well as the need to analyze HAI data in a site-specific manner, as differences occur between acute care facilities.

Prevalence calculations that stratified by UTI type showed variation, facility-wide and by floor, for each of 3 types of UTI. This result justified stratification by UTI type in further data analysis. Different floors experienced different issues with regard to UTI prevalence, with a particularly high burden of infection for ICP on the 21 and 22 floors, and a high burden of no device UTIs on the 21-25 floors. Rates of infection within the same UTI type varied by floor, justifying the comparison of infection rates on different floors of SRAlab. CAUTI rates were highest on floors 19, 20, 21, 22, and 24. ICP rates were highest on floors 18 and 20. No device infection rates were highest on the 23rd floor. Prevalence data, in addition to infection rates, indicate the differing patient populations on each floor may account for some differences in infection parameters by floor.

Prevalence and infection rate data, when stratified by floor and UTI type, showed that different floors of the hospital incur different types of UTI infection prevention issues. As the SRAlab floors contain different types of patient populations within each floor, with some floors discussed in detail below, this result is understandable. Target interventions by each floor should address any patient populations with increased relative risk of incurring a UTI relative to the general hospital population. Specifically, healthcare protocols for intermittent catheter utilization, insertion technique, and care should be reviewed and targeted for improvement on floors 18 and 20.

The 18^{th} floor is a medically complex pediatric unit where, due to the physical therapy needs of the pediatric population, foley catheter utilization is very rare and intermittent catheter utilization is higher. In this unit containing medically complex, non-adult patients, patient morbidity is higher than adults on other floors, due to issues like active chemotherapy. Similarly, the 20^{th} floor of SRAlab patient population is medically complex, with immunocompromised and cancer patients, and adults with multiple comorbidities. The presence of less healthy populations on the 18^{th} and 20^{th} floor could be an underlying cause of higher relative risk of intermittent catheter use, and specific interventions should be targeted to improve processes on these floors.

The 23^{rd} floor, where there is an increased risk of UTI when no device exposure is present compared to using any device, is a floor containing many stroke patients with neurogenic bladder disease. Stroke patients have retention problems or acute neurogenic bladder. Chronic neurogenic bladder is observed more on 21/22 spinal cord units. Interventions targeting incontinence bladder training and UTI prevention in patients without devices on these floors are a worthwhile focus.

The relative risk values show that, despite the high number of no device UTIs occurring at SRAlab, there is still an increased risk of acquiring a HA-UTI when using any alternative voiding device. There may be increased odds on the 23rd floor, and it is worthwhile to look into process improvement with regard to urinary tract infection prevention in patients without devices on this floor. Other factors that may contribute to increased risk of non-device UTI, like gender or previous UTI history, were not addressed in this study and would be a worthwhile future direction for this research. The patient population most worth targeting at SRAlab, from prevalence, infection rate, relative risk values, and odds ratios, is the patient population utilizing intermittent catheter devices, especially on the 18th and 20th floors. CAUTI infections are relatively infrequent and have low relative risk of infection, indicating sterility during foley catheter insertion procedures and sterile upkeep are likely functioning well in this patient population.

The relative risk of exposure to a foley catheter device often yielded ratios less than 1, indicating that exposure to a foley catheter could be protective against urinary tract infection. This result is unexpected, as both the insertion process of an invasive foley catheter device, as well as the risk of biofilms forming on the catheter device while it is in use, predict the opposite result. At SRAlab, however, it is possible that the preventative care techniques and caution used by healthcare providers when inserting and caring for patients with foley catheters, results in these patients receiving a level of hygienic care above that used for patients without a device. This possibility, coupled with the high overall proportion of no device UTI infections at SRAlab compared to total infections of all types, could result in a relative risk ratio less than 1. The result does not imply that the foley catheter itself is protective.

The stakeholders in this study are the patient population at SRAlab, the infection prevention department at SRAlab, and healthcare providers at SRAlab. The results of this study will be communicated to stakeholders during a regularly-occurring infection prevention meeting where clinicians, facility managers, infection preventionists, and healthcare administrators meets to discuss future infection prevention interventions and the results of prior infection prevention interventions. Experiencing a UTI while at SRAlab may delay a patient’s rehabilitation goals by extending the length of stay, delaying the rehabilitation process due to illness, as well as causing negative side effects of necessary antibiotics during UTI treatment. The conclusions drawn from this population may have relevance outside the SRAlab, applying to other rehabilitation hospitals and long term care facilities with similar patient demographics.

Table and Figure Captions

Table 1: Infections were categorized by anatomical site. Other infections represent infections that do not fit into the larger categories, such as infections from cerebrospinal fluid, abscess drainage, or tissue biopsy. After collecting data from all infections cultured, infections from patients with a length of stay (LOS) shorter than 2 days were removed, as they did not fit the criteria for hospital-acquired (HA) infection. Then, infections that met the criteria for symptomatic infections were separated from all

cultures. The percentage of hospital-acquired infections represent the number of infections in patients with a length of stay greater or equal to 3 days that were also considered symptomatic. The denominator in this calculation is the total number of infections of all types that met the criteria of being symptomatic and hospital-acquired.

Table 2 and Figure 1: Infections were categorized by UTI type: Catheter-associated UTIs (CAUTI), Intermittent catheter-associated UTIs (ICP), and UTIs not associated with any device. The proportion of total infections references the total number of symptomatic infections in Table 1, 512.

Table 4: The relative risk of UTI when using a CAUTI, ICP, or any device was compared to a control population on the same individual floor or facility wide. The relative risk of CAUTI was compared to the risk of any other type of UTI. The relative risk of ICP was compared to any other type of UTI. The relative risk of using any device was compared to not using a device.

Table 5: The odds of acquiring a UTI was calculated by hospital floor or facility wide. The odds of CAUTI were compared to getting any other type of UTI. The odds of ICP were compared to getting any other type of UTI. The odds of getting a UTI with no device were compared to using any device, ICP or CAUTI.

Table 1: Summary Statistics for All Infections

Infection Type	N Cultures	N Infections LOS >2	N Symptomatic Infections	% HA Infections
Wound	106	97	2	2.06
Blood	73	65	18	27.69
Respiratory	315	287	44	15.33
Other	3	3	1	33.33
Stool	70	N/A	69	N/A
Urine	1407	1269	378	29.79
All Types	1974	1721	512	29.75

Table 2: Summary Statistics for all Urinary Tract Infection (UTIs)

Type of UTI	N Cultures	N Symptomatic Infections	% Total Symptomatic Infections	% Total UTIs
CAUTI	106	31	6.05	8.20
ICP	733	140	27.34	37.04
No Device UTI	568	207	40.43	54.76
All Types	1407	378	73.83	100

Figure 1: Different Types of UTI as a Proportion of Total Symptomatic Infections

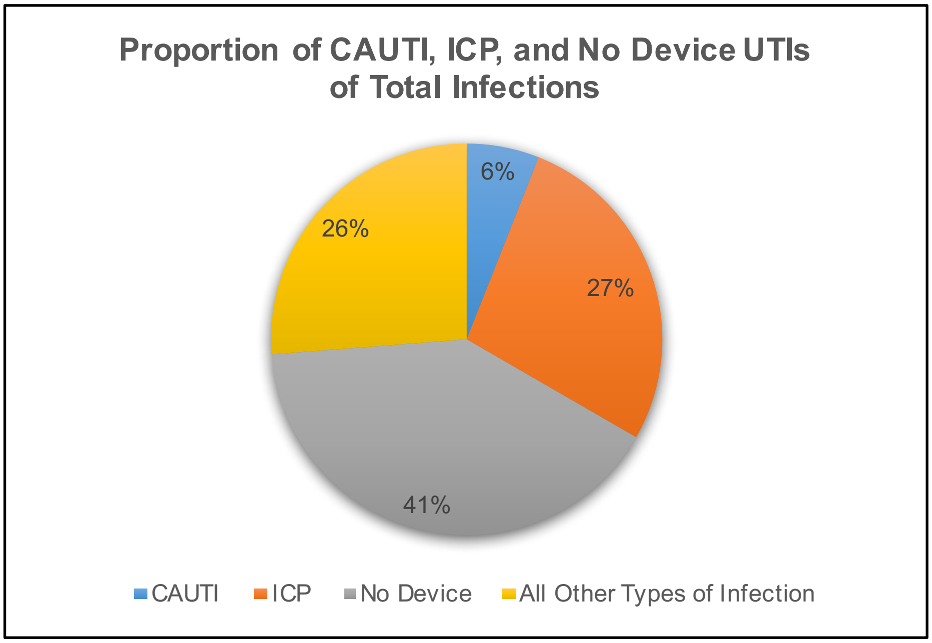

Figure 2: Prevalence of UTIs by Type of UTI and Hospital Location (UTIs/Admissions)

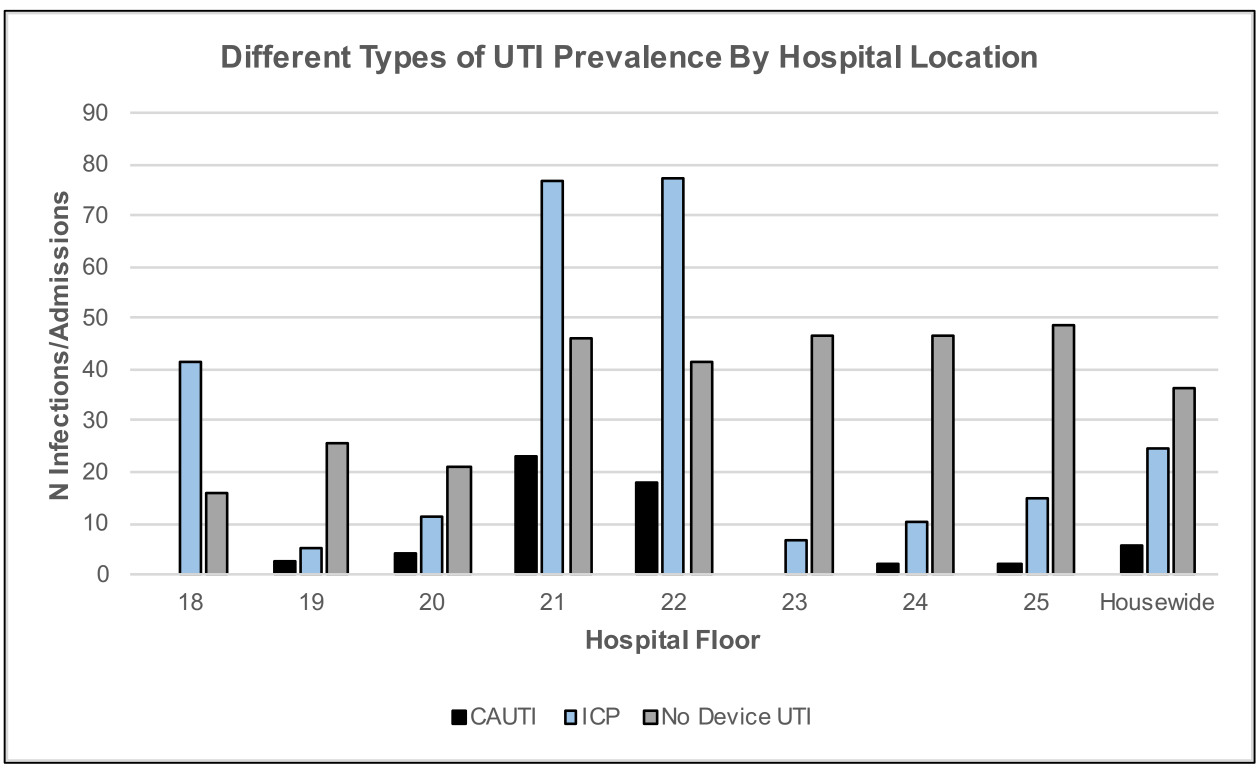

Figure 3: Infection Rate of CAUTI by Hospital Location

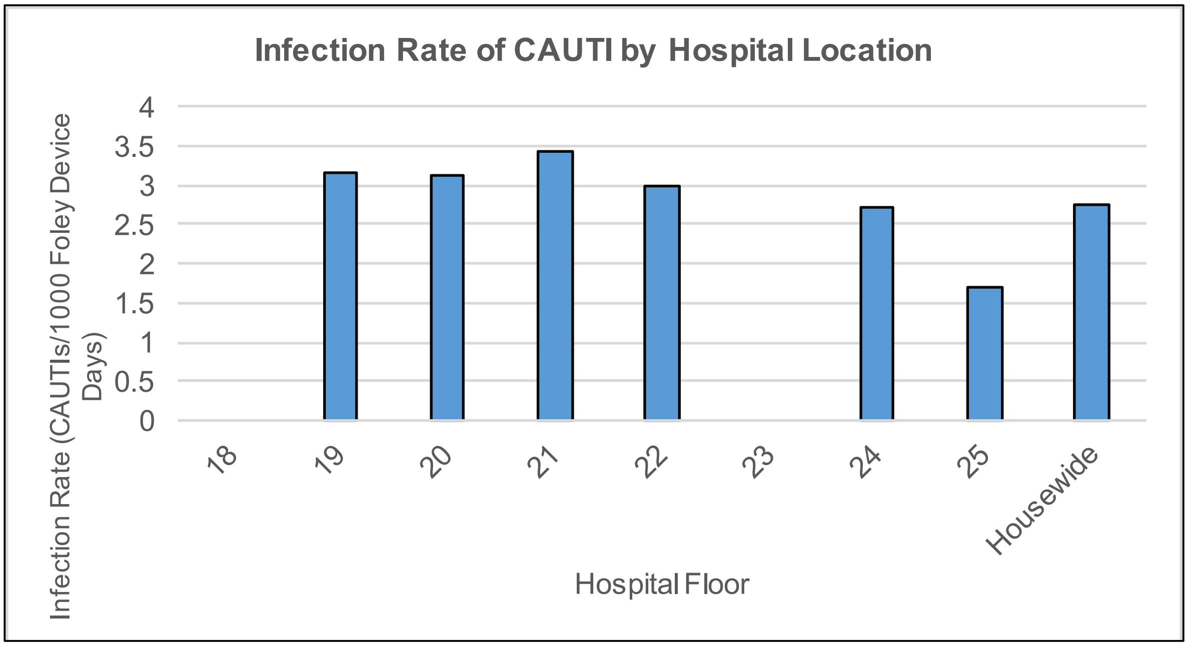

Figure 4: Infection Rate of ICP by Hospital Location

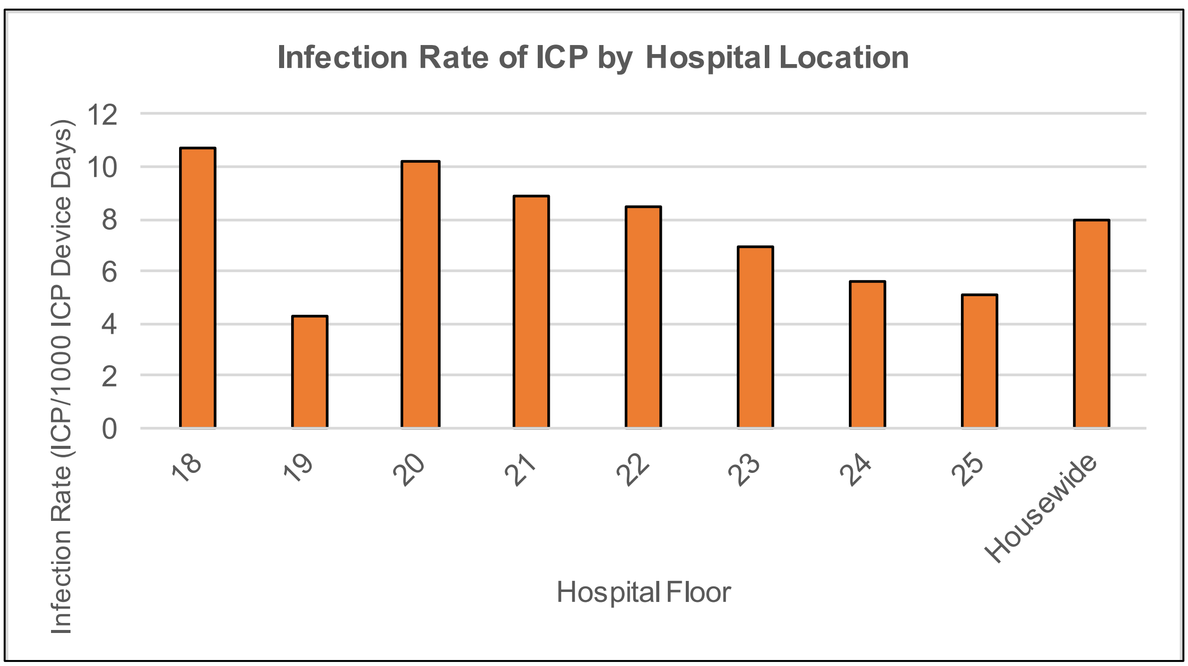

Figure 5: Infection Rate of No Device UTI by Hospital Location

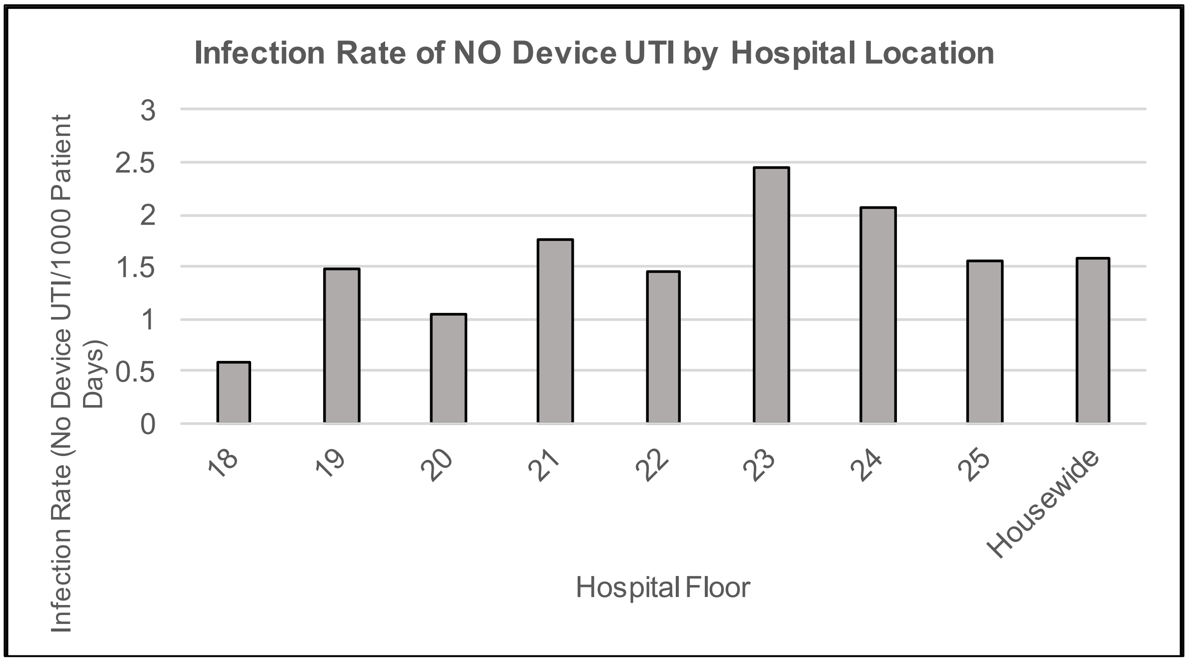

Table 4: Relative Risk of Types of UTI by Hospital Location

Location	**Facility Wide**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
RR CAUTI	0.50		0.71	1.35	0.36	0.28		0.33
RR ICP	3.03	18.76	1.98	4.38	1.72	1.79	1.28	1.54
RR Any Device	1.81	11.48	1.28	3.34	0.78	0.68	0.57	0.90

Table 5: Odds Ratios of Types of UTI by Hospital Location

Location	**Facility Wide**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
OR CAUTI	0.49		0.70	1.37	0.31	0.24		0.31
OR ICP	3.39	27.85	2.05	4.84	1.90	1.97	1.30	1.59
OR No Device	0.53	0.07	0.77	0.28	1.35	1.56	1.79	1.12

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