ECONOMIC EVALUATION OF A CAUTI PREVENTION PROGRAM IN NURSING HOMES

Short Running Title: Economics of CAUTI Prevention in Nursing Homes

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Trial Registration: clinicaltrials.gov Identifier: NCT01062841

Grant Support: This study was supported by RO1AG032298 from the National Institute on Aging (Drs. Mody, Krein, and Saint), by K24 AG050685 from the National Institutes of Health (Dr. Mody), by RO1AG041780 from the National Institute on Aging (Dr. Mody), and by the Claude D. Pepper Older American Independence Centers funding from the National Institute on Aging (Dr. Mody).

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Abstract Word Count: 250

Text Word Count: 2838

Number of tables/figures: 2 tables, 1 figure

Impact Statement: We certify that this work is novel in providing an economic evaluation of a targeted infection prevention program in nursing homes. We believe that this is one of the first studies that has conducted an economic evaluation of a focused infection prevention program, particularly in the nursing home setting. With the burgeoning short-stay population, reducing readmissions to hospitals is a priority. Infection is the most common reason for readmission. Our study conducts an economic evaluation of a targeted program.

ABSTRACT

Background: A randomized clinical trial of a targeted infection prevention intervention in nursing homes (NHs) demonstrated reductions in catheter-associated urinary tract infections (CAUTI), yet cost-effectiveness is unknown.

Objective: Assess the economic impact and cost effectiveness of the intervention in the NH setting.

Design: Costs of the intervention, costs of disease, and health outcomes were used to calculate an incremental cost-effectiveness ratio for the intervention. Data came from intervention results and the literature and outcomes were analyzed over one year.

Design, Setting, Participants: Randomized clinical trial of 418 high-risk NH residents with indwelling urinary catheters at 12 community-based NHs.

Intervention: Standard care versus infection prevention program involving barrier precautions, active surveillance, and NH staff education.

Measurements: Costs of the program, costs of disease, health outcomes, and incremental cost-utility ratios.

Results: A 120-bed NH would have program costs of $20,279/yr. The cost of disease treatment would be reduced by $54,316 per year, resulting in a $34,037 net cost savings. Most of this savings would come from reduced CAUTI hospitalizations ($39,180), with $15,136 in savings from CAUTI care within the NH. The intervention also yielded a gain of 0.197 quality-adjusted life-years (QALYs). Probabilistic sensitivity analysis shows the intervention was 85% likely to result in a reduction in costs.

Conclusions: The CAUTI prevention program is expected to benefit payers by reducing costs and improving the health outcomes. Since the savings accrue to payers and not to the NHs, payers such as Medicare and private insurers may want to incentivize the implementation of such programs.

Trial Registration: clinicaltrials.gov Identifier: NCT01062841

Keywords: Cost-Effectiveness; Drug Resistance, Multiple; Catheter-Related Infections; Nursing Homes

At any given time, there are more people in nursing homes (NHs) in the United States than in hospitals, making NHs a crucial part of the healthcare system in the U.S.[1] With a predominantly frail older population with a high acuity of illness, nosocomial infections are common and often severe in NHs, resulting in frequent hospital transfers and an estimated $2 billion in hospital expenditures per year.[2]

NH residents at risk of infection share several commonalities including indwelling devices, prior antimicrobial usage, recent hospitalization, and functional impairment.[3,4] Recent national data show that about 12%–15% of new admissions to NHs have an indwelling urinary catheter and 5%–10% have chronic urinary catheters.[5,6] Thus, on any given day, 80,000-150,000 of the 1.5 million NH residents have an indwelling urinary catheter.[7] Unlike acute care settings with shorter lengths of stay, even appropriately placed urinary catheters in NH residents often remain in place for prolonged periods, with an average duration of 105 days per catheterized resident.[8] These catheters are responsible for the largest institutional reservoir of multi-drug resistant organisms (MDROs) and their presence doubles the risk of symptomatic infections.[3,9] More than 50% of episodes of fever in individuals with chronic indwelling urinary catheters are from a urinary source, with an incidence of about 1 per 100 catheterized resident-days.[3] Some of these catheter-associated urinary tract infections (UTIs) will lead to bacteremia, sepsis, and death.[3,4] The Centers for Medicare and Medicaid Services' (CMS) recent reform of the requirements for nursing facilities requires that facilities have an infection prevention and control program and designate an infection preventionist. The estimated cost of this infection control preventionist is expected to be $19,032 per facility per year.[10] And, CMS does not have an estimate of the benefits of this type of program.

In a recent interventional study, we evaluated the effectiveness of a three-year Targeted Infection Prevention (TIP) multi-modal intervention program in reducing MDRO prevalence and device-associated infections in a group of 12 NHs in Southeast Michigan.[8] The intervention included a structured interactive educational program for NH staff, hand hygiene promotion, preemptive barrier precautions when assisting with high-risk activities of daily living, and active surveillance for MDROs and infections with monthly data feedback all supported by an infection preventionist. This intervention led to a 23% reduction in the overall MDRO prevalence density rate, a 31% reduction in all clinically diagnosed catheter-associated urinary tract infections (CAUTI) [8]. In addition, we document 30% fewer hospitalizations among residents with CAUTI.[8] To further enhance the usefulness of our findings, we sought to answer the question: Is the targeted intervention cost-effective for an average NH? Previous studies have reported on the effectiveness of CAUTI reduction interventions in hospital settings, showing cost reductions and significant decreases in morbidity.[11-13] However, very few studies have included cost-effectiveness analyses in order to make a business case to devote resources to infection prevention programs in NHs and other long-term care settings.[14-16] In this paper, our primary aim was to examine the economic impact of our intervention program.

METHODS

To achieve our aims, we used a cost-effectiveness analysis framework. Our goal was to determine whether the benefits from the TIP intervention program exceeded the costs, and if not, how much was actually being paid per unit of health outcome gained. This retrospective analysis of the program was conducted to assist NH administrators and policy makers in evaluating its success and facilitate future implementation. This TIP study is a multicenter randomized clinical trial evaluating a multimodal practical evidence-based program to reduce CAUTI in nursing homes.[8] This cluster randomized study, which was approved by the University of Michigan Institutional Review Board, was conducted in 12 (6 control, 6 intervention) community-based NHs in Michigan. Both intervention and control sites had similar infection prevention programs at baseline.[8] The intervention took place over three years. Although about 50% of residents with indwelling devices at the NHs provided consent and were enrolled in the program, we predict that the benefits of the intervention apply to the care of all NH residents at the facility including short-stay residents and long-stay residents.

We conducted the cost-effectiveness analysis from the health care system perspective. We look at the impact of the intervention on a representative single NH over one year, applying reductions in adverse events observed in the trial to all residents with indwelling urinary catheters. The intervention observed a reduction of CAUTIs from 9.2 per 1000 device-days to 5.9 per 1000 device days with the intervention.[8] Hospitalizations for CAUTI were 3.7 per 1000 device days in the control group and 2.6 per 1000 device days in the intervention.[8] These outcomes are modeled in this analysis which then affect costs and quality-adjusted life-years (QALYs) lost (Figure 1).

In addition to the base-case cost-effectiveness analysis, costs and outcomes were also calculated from the perspective of just the NH (ignoring costs outside the NH like hospitalization) to assess how the intervention might affect the NH alone. Only the costs of the intervention and the costs of health outcomes affected by the intervention were used in our calculations; the costs of standard NH care were not included and were assumed to be equal for the intervention and control NHs (Table 1). Costs and outcomes were calculated for a representative 120-bed NH with 6% of residents having indwelling urinary catheters,[5] using the annual rates observed over the three-year intervention and applied to all residents having indwelling urinary catheters.

Intervention Costs

All costs are expressed in 2015 U.S. dollars. The intervention costs include the cost of an infection prevention specialist to lead and oversee the intervention program, nursing personnel cost to attend educational activities, nursing time for donning protective equipment, as well as supplies for hand hygiene activities, barrier precautions and interactive educational materials (Table 1). We did not include costs of active surveillance for MDRO's which were used for research evaluation purposes. Resource utilization for the six intervention NH sites were evenly divided to calculate per-NH resource utilization. Additional details on the calculations of these intervention costs are in the supplemental text S1.

Disease Costs

The cost of CAUTI treatment in a NH, the cost of hospitalization due to a CAUTI, and the cost of hospitalization due to CAUTI-associated septicemia were incorporated into the disease cost analysis.[17-20] The cost of CAUTI treatment in a NH was estimated to be $1,745 per infection episode.[21] The Office of Inspector General of the Department of Health and Human Services has reported on the costs specifically related to hospitalizations from NHs. They report that the average cost of hospitalization due to a CAUTI was $13,554 in 2011, while the cost of hospitalization due to septicemia was reported to be $19,914 per episode.[18] A weighted average of the cost of hospitalization due to a CAUTI and the cost of hospitalization due to a CAUTI-related septicemia was used to calculate the overall average cost of CAUTI care in a hospital. We assume that 50% of NH hospitalizations for CAUTI have a primary diagnosis of septicemia (Table 1).[20] Additional details on hospitalization cost calculations can be found in the supplemental text S1. As NH residents are usually not employed, opportunity costs of infection and hospitalization were not included.

Utilities

The health outcomes of the intervention were calculated in terms of QALYs lost related to CAUTI (Table 2). Utility scores came from the literature.[22-24] These studies average utilities over a mix of residents who were hospitalized and not hospitalized. The utility score decrement during the course of a CAUTI was estimated to be 0.09 and the average duration of a CAUTI was taken to be 14 days in the base case.[23-24] Long-term utility loss due to CAUTI was estimated to be 0.02.[22] The long-term utility loss was assumed to occur for the remainder of the year.

Evaluating the Value of the TIP Intervention Program

If the TIP intervention program results in lower NH costs and fewer QALYs lost from disease than the control, it is said to be cost-saving. In that case, we record the costs saved and QALYs

gained. In the case where the TIP intervention would lead to higher costs and fewer QALYs lost than the control, the important consideration is whether the QALYs saved are worth the extra cost. In that case, we compute an incremental cost-effectiveness ratio (ICER) defined as:
(Cost of Intervention – Cost of Control) / (QALYs lost with Control – QALYs lost with Intervention). We have included the CHEERS checklist (supplemental table S1) to help readers understand and find many of the details of this analysis.

Sensitivity Analysis

We conducted univariate sensitivity analysis on all variables in our model. We also conducted a probabilistic sensitivity analysis, using Monte Carlo simulation to simultaneously vary parameter assumptions to quantify overall uncertainty in the results in cost effectiveness acceptability curves. Assumptions about the variability of the parameters used for the univariate and probabilistic sensitivity analyses are in Table 1.

RESULTS

Base-Case Analysis

Our analyses show that the implementation of a TIP intervention program would lead to 8.7 fewer CAUTI and 2.9 fewer resident hospitalizations per NH per year. The intervention would cost $20,279 for the NH over the course of a year, with disease costs under the intervention of $119,669, for a total of $139,948. This is lower than the $173,986 in disease costs for the control group in the TIP study. The intervention saved $15,136 in NH CAUTI care and $39,180 in hospital care for CAUTI and CAUTI-associated septicemia for a total net savings of $34,037 for the health care system, as well as a gain of 0.2 QALYS compared to the control (Table 2).

The intervention costs were estimated to be $11,458 for the time of an infection control specialist, $1,133 for other staff in-service time, $5,326 for staff time donning protective equipment, and $2,361 in supplies and printing. However, the primary costs were disease-related costs. A majority of the costs were due to CAUTI care in a hospital. If the NH was responsible for the costs of the intervention and CAUTI care within the NH, but not responsible for costs of CAUTI care in the hospital, the NH would have a net cost increase of $5,143.

Sensitivity Analysis

We first varied all input parameter assumptions one-at-a-time to see how they affected the value of the TIP intervention program. The variables that most substantially affect the costs saved are the rates of hospitalization for CAUTI (Table S2). If the intervention reduces the rate of hospitalizations from 3.7 to 3.55 per 1000 device-days (9.7 per year to 9.3 per year for the NH), the TIP intervention would be cost-saving (Figure S1). In the probabilistic sensitivity analysis, the TIP intervention is 85% likely to be cost-saving and 96% likely to be cost-effective at a threshold of $200,000/QALY (Figure S2).

DISCUSSION

This cost-effectiveness analysis shows that the TIP intervention program is expected to save $34,000 per year and improve health outcomes by 0.2 QALYs. A systematic review of the cost-effectiveness analysis literature showed that only 20% of prevention interventions evaluated in cost-effectiveness analyses are found to be cost-saving,[25] meaning they improve health and result in a reduction in costs. Finding interventions that are cost-saving is difficult because the right interventions have to be applied in the correct settings to the appropriate residents. The TIP program is one of the few interventions that both saves money and improves health outcomes by reducing infections and related hospitalizations in a high-risk setting and population.

However, when viewed solely from the financial perspective of the NH alone, it may not appear to have net cost savings. We show that a focused risk-factor-based intervention would cost about $20,000 per year to the NH but lead to about $15,000 in annual savings from reduced CAUTI care within the NH, for a net cost to the NH of about $5,000. Most of the benefits to the overall health care system result from $40,000 of reduced CAUTI care in hospitals, which are savings likely captured by payers. This suggests that payers, who benefit the most from an intervention like TIP, may find it financially worthwhile to incentivize NHs to conduct similar infection control programs that promote consistent application of evidence-based practices in high-risk populations. CMS estimates the cost of its new broad infection control program would be $19,032 per NH per year, which is a significant underestimation since it only includes cost of the infection preventionist.[10] Additionally, CMS fails to account for the benefits to both the NH and the health system of the reduced infections and hospitalizations.[10]

These findings should be placed in context with recent infection prevention initiatives in other healthcare settings. A systematic review of hospital-based infection prevention interventions found seven recent studies in the US evaluating the net economic impact of the programs.[26] All seven found the programs had cost savings in excess of the intervention costs. Since that review was conducted, several additional studies have been published.[27-29] A recent study[27] of a multifaceted quality improvement program to reduce central line-associated bloodstream infections in intensive care units (ICUs) found that the intervention prevented 42 central line-associated bloodstream infections, 6 deaths, and saved $249,000 per 1,000 patients. Another study[28] of infection precautions to prevent methicillin-resistant *Staphylococcus aureus* (MRSA) transmission in U.S. ICUs found that universal decolonization would avert 246 infections and save $2.81 million per 10,000 ICU admissions, and that universal contact precautions plus decolonization would avert an additional 66 infections per 10,000 admissions, but at a cost of $9,007 per incremental infection averted. In a third study,[29] researchers evaluated multifaceted infection prevention programs designed to decrease central line-associated bloodstream infections and ventilator-associated pneumonia in ICUs. They found that the intervention improved health and saved initial inpatient costs; however, even though long-term costs increased (partially due to increased life expectancy post-discharge), the intervention was still cost-effective at $23,278/QALY gained. These studies provide evidence that multifaceted programs to reduce infections in healthcare settings can indeed be cost-saving or cost-effective. But, they were all in ICU settings. Our results build on this evidence and show that in a NH setting, similar interventions can be cost-saving and improve health outcomes for NH residents.

Our study has several limitations. In the analysis for a representative NH, we assumed other NH residents who did not consent to participate in the TIP intervention program would have similar reductions in the rates of CAUTI. We felt this was a reasonable assumption, given the program was geared towards all residents. Furthermore, the intervention in the trial included active surveillance for MDROs in order to evaluate study outcomes. Because this is neither practical for a typical NH nor the current standard of care, we did not include that as part of the cost-effectiveness analysis. However, it is possible the active surveillance may have had an additional effect on the study results.

The analysis also may have underestimated the impact of CAUTI prevention in several ways. First, although the results indicated a reduction in MRSA colonization, we did not incorporate these costs into the analysis due to limited information on the cost effectiveness of preventing MRSA colonization. Presumably, however, the decreased colonization of pathogens should lead to fewer infections in NH populations and would extend the cost-savings of this program. Second, we did not evaluate the benefits of reduced MDRO transmission to other NH residents, which could lead to further infection reductions in MDROs, as well as other pathogens. It is possible that reductions in infections could also lead to reductions in mortality. However, the study was not powered to detect differences in mortality, so we did not include it as an outcome measure. This may lead to an underestimate of the benefits of the intervention. Finally, we did not measure the impact of this type of intervention on other aspects of broad-based infection prevention. For example, increased adherence with hand hygiene guidelines may reduce overall nosocomial infections beyond NH residents with indwelling urinary catheters.

This study also has several strengths. Our results are based on a randomized, controlled intervention study of 12 NHs in Southeast Michigan. We believe the results are generalizable to other NH populations. The intervention was comprehensive and designed to affect all NH residents, not just those at high-risk. Importantly, we evaluate the results from several perspectives and find that the multicomponent intervention may be viewed differently from the perspective of the NH itself versus the payer and the health care system as a whole. Because the program is expected to have a net cost to the NH (cost of the program outweigh CAUTI savings within the NH), there may be a need to provide incentives to NHs to enact these types of interventions. The overall benefits to the health system of infection prevention interventions, along with the benefits to payers provide sufficient value and cost benefits to be shared with NHs. In addition, new organizational structures such as Accountable Care Organizations may be ideal platforms to align incentives between NHs, hospitals, residents, and payers as these organizations may share benefits and savings. Nursing homes that implement these types of interventions may be more attractive to hospitals looking for preferred locations for post-acute care in their networks.

ACKNOWLEDGMENTS

Conflict of Interest Disclosures:

Elements of Financial/Personal Conflicts	*Author 1 DW		Author 2 SK		Author 3 SS		Author 4 NG	
	Yes	No	Yes	No	Yes	No	Yes	No
Employment or Affiliation		X		X		X		X
Grants/Funds		X	X		X			X
Honoraria		X		X		X		X
Speaker Forum		X		X		X		X
Consultant		X		X		X		X
Stocks		X		X		X		X
Royalties		X		X		X		X
Expert Testimony		X		X		X		X

Board Member		X		X		X		X
Patents		X		X		X		X
Personal Relationship		X		X		X		X

***Authors can be listed by abbreviations of their names.**

For "yes" x mark(s): give brief explanation below:

NIA RO1AG032298 (SK, SS, LM); NIH K24 AG050685, NIA RO1AG041780, and Claude D. Pepper Older American Independence Centers funding from NIA (LM); and VA Health Services Research and Development Service Research Career Scientist Award (SK)

Author Contributions: Dr. David Hutton had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Drs. Hutton and Mody contributed to the concept and design. All authors were involved in acquisition, analysis, and interpretation of data. Drs. Hutton, Mody, Krein, and Saint drafted and revised the article critically for important intellectual content. All authors reviewed and approved the submitted version of the article.

Sponsor's Role: The sponsor was not involved in the study design, methods, subject recruitment, data collections, analysis, or preparation of the paper. The content is solely the responsibility of the authors and does not necessarily represent the official views of the funders.

Elements of Financial/Personal Conflicts	***Author 5 AK**		**Author 6 RL**		**Author 7 LM**			
	Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Employment or Affiliation		X		X		X		
Grants/Funds		X		X	X			
Honoraria		X		X		X		
Speaker Forum		X		X		X		
Consultant		X		X		X		
Stocks		X		X		X		
Royalties		X		X		X		
Expert Testimony		X		X		X		
Board Member		X		X		X		

Patents		X		X		X		
Personal Relationship		X		X		X		

For "yes" x mark(s): give brief explanation below:

NIA RO1AG032298 (SK, SS, LM); NIH K24 AG050685, NIA RO1AG041780, and Claude D. Pepper Older American Independence Centers funding from NIA (LM); and VA Health Services Research and Development Service Research Career Scientist Award (SK)

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Title of Supplemental material: Additional Details on Methods and Results.

Supplemental Text S1: Detailed Intervention Costs

Supplemental Table S1: CHEERS Checklist

Supplemental Table S2: Sensitivity to Parameters

Supplemental Figure S1: Sensitivity on Rate of Hospitalization

Supplemental Figure S2: Cost Effectiveness Acceptability for a Representative Nursing Home

Figure Legends.

Figure 1. Schematic of decision tree model. The figure should be read from left to right. The square represents the intervention decision. Circles represent uncertain outcomes for nursing home residents: whether they get a catheter-associated urinary tract infection (CAUTI), whether they are hospitalized, and whether they have septicemia, given hospitalization.

Table 1: Input Parameters

Parameters	Base	Min	Max	Source
Intervention Effectiveness				
Percent of residents with catheter	6%	5%	7%	Rogers et al. [5]
Clinically defined CAUTI per 1000 device days*				
Control	9.2	7.38	11.57	Mody et al.[8]
Intervention	5.9	4.59	7.72	Mody et al.[8]
Hospitalizations per 1000 device days*				
Control	3.7	2.60	5.28	Mody et al.[8]
Intervention	2.6	1.76	3.85	Mody et al.[8]
Intervention Cost Parameters				
FTE's required	0.21	0.17	0.25	Mody et al.[8]
Infection Control Annual Salary	$55,000	$41,250	$68,750	Mody et al.[8]
Educational Activities				
Nurses Hourly Wages	$32	$24	$40	Mody et al.[8]
Nurses Hours for Intervention Training	16.67	12.50	20.83	Mody et al.[8]
Nursing Aid Hourly Wage	$12	$9	$15	Mody et al.[8]
Nursing Aid Hours for Intervention Training	50	37.50	62.50	Mody et al.[8]
Additional Resident Time				
Gown and Glove Donning Time (minutes) per Resident Visit for Intimate Activities of Daily Living (with Indwelling Device)	0.63	0.27	1.00	Martin et al.[17]
Resident Visits for Intimate Activities of Daily Living per Day	6.00	4.00	8.00	assumption
Supplies	$2,000	$1,500	$2,500	Mody et al.[8]
Printing	$361	$271	$451	Mody et al.[8]
Costs of Disease				
Cost of CAUTI in Nursing Home	$1,745	$1,500	$2,000	Maki et al.[21]
Cost of Hospitalization				
Cost of Hospitalization due to CAUTI	$7,193	$5,395	$8,992	OIG report.[19]
Cost of Hospitalization from Septicemia	$19,914	$14,936	$24,893	OIG report.[19]
Fraction of CAUTI leading to septicemia	0.5	0.25	0.75	OIG reports.[18,19]
Utilities				
Length of CAUTI symptoms	14	7	14	Hout et al. [22]
Utility loss per CAUTI	-0.09	-0.04	-0.14	Maxwell et al. [24]
Long term utility loss due to CAUTI	-0.02	0	-0.05	Hout et al. [22]

The “Base” column contains values used for the base case analysis. The “Min” and “Max” columns are used for sensitivity analysis. In the probabilistic sensitivity analysis, the parameters are assumed to be normally distributed with the base representing the mean and the min and max representing a 4 standard deviation spread (roughly 95% of the distribution). Additional details on how these parameters were calculated are in the supplemental text.

FTE: full-time equivalent

NH: nursing home

CAUTI: catheter-associated urinary tract infections

* Rates are per 1000 days a catheter device is inserted in a resident

Table 2. One Year Health and Cost Outcomes for a Representative 120-bed Nursing Home

	Intervention	Control
Health		
CAUTI	15.5	24.2
Hospitalizations due to CAUTI	6.8	9.7
QALYs lost from CAUTI	0.35	0.55
Costs		
Intervention Costs	$20,279	$-
Disease Costs		
CAUTI Care in Nursing Home	$27,061	$42,197
CAUTI Care in Hospital	$92,608	$131,789
Disease Subtotal	$119,669	$173,986
Total Costs	$139,948	$173,986
Interpretation:	Cost Savings of $34,037	

QALY: quality-adjusted life-year
CAUTI: catheter-associated urinary tract infections

Supplementary Text S1:

Detailed Intervention Costs

Program implementation required 1.25 (1-1.5) nurse FTEs for the six NH (NH0 trial. The average fully loaded salary for this position was $55,000. The cost of implementation in the trial was calculated to be (1.25 FTEs)*($55,000)=$68,750 for one year. From this, the estimated implementation costs for a single representative NH was taken to be (1.25 FTE/6)*($55,000) = $11,485 for one year.

The second category of costs was the cost of nurse and nursing aid (NA) in-service costs. 200 healthcare professionals completed four in-services each in the six NH trial. The average length of each in-service was estimated to be 30 minutes, yielding 400 total hours of in-services. It was estimated that one fourth of the healthcare professionals in the trial were nurses and the remaining three fourths were NAs. Average hourly wage for nurses was $31.84 and that of NAs was $11.97. The total cost of in-services was calculated as follows: (hours of nurse in-service)*(nurse hourly wage)+(hours of NA in-services)*(NA hourly wage)=$6,775 per year for all six NHs, or 1,129 per NH.

The third category of costs is for nurse donning personal protective equipment. We took estimates of 38 seconds per room entry for doffing from Martin EM, et al.[17] We estimated that the intervention would involve 6 additional patient visits per day requiring donning of personal protective equipment for nurses visiting patients with indwelling devices for intimate activities of daily living. The total cost of time for donning protective equipment was calculated as follows: (minutes per room entry) / (60 minutes per hour) x (patient visits per day) x (patients with indwelling devices) x (365 days per year) x (nurse hourly wages) = $5,326 per NH or $19,077 over the 9413 device-days experienced in the entire 6 NH trial.

The last category of intervention costs comprises the cost of supplies. The cost of printing posters and educational materials for 6 NHs was estimated to be $2,167, or $361 per NH per year. Costs related to gowns, gloves and hand hygiene products was estimated to be $12,000 per year in the 6 NH trial, which corresponds to a cost of $2000 per NH per year. In total, the cost of supplies and printing was calculated to be $14,167 per year for six NHs or $2,361for a single NH.

Septicemia

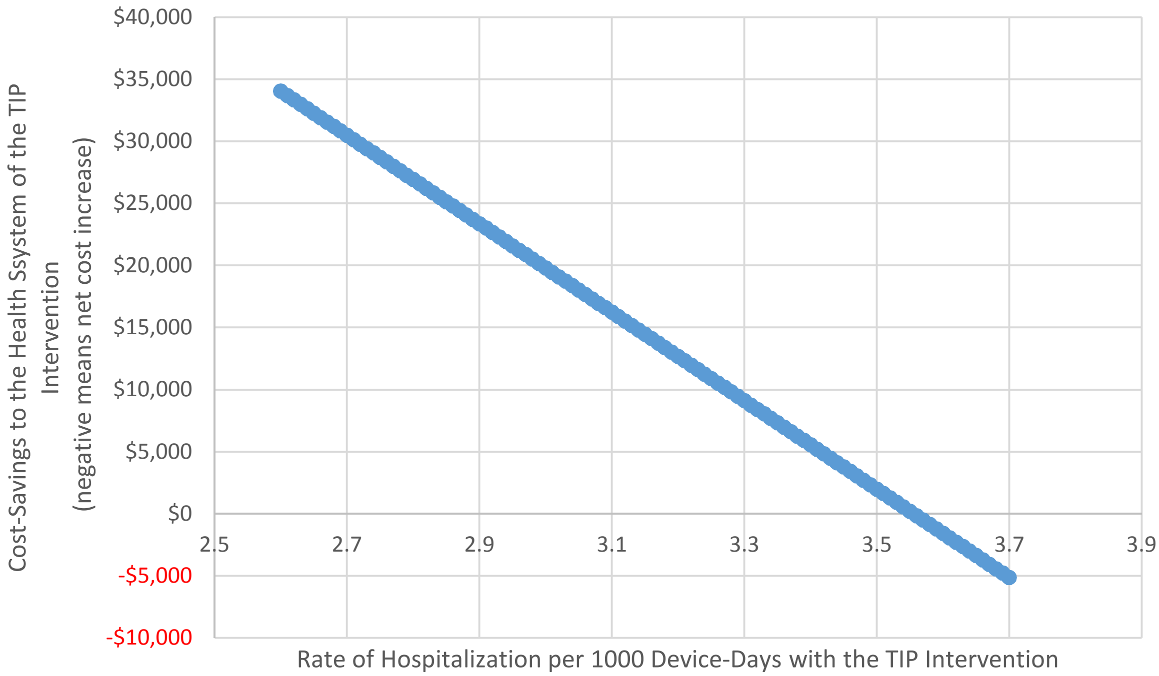
For costing purposes, we are interested knowing the number of urinary tract infections (UTIs) that lead to a hospitalization with an expensive primary diagnosis of septicemia. To do this, we examine data on admissions for primary diagnosis of septicemia and primary diagnosis of UTI. We then look at primary septicemia admissions with a secondary diagnosis of UTI.

The report, "Adverse Events in Skilled Nursing Facilities: National Incidence Among Medicare Beneficiaries" (OEI-06-11-00370),[18] suggests that Nursing Home events leading to sepsis are generally related to UTI or pneumonia (Table F1 of that document).

Another document by the Office of Inspector General, "Medicare Nursing Home Resident Hospitalization Rates Merit Additional Monitoring" (OEI-06-11-00040),[19] notes that 13.4% of all hospitalized Medicare NH residents had a primary diagnosis of septicemia and 5.3% had a primary diagnosis of UTI on claims in FY 2011. An AHRQ report on septicemia[20] suggests that 43.3% of all hospital admissions with a principal diagnosis of septicemia had a secondary diagnosis of a UTI. This analysis was of all US hospitalizations, but we assume it holds for hospitalized NH patients. Combining this information, if we look at primary and secondary diagnoses of septicemia and UTI's, we have 5.8% (13.4% x 43.3%) of all hospitalized

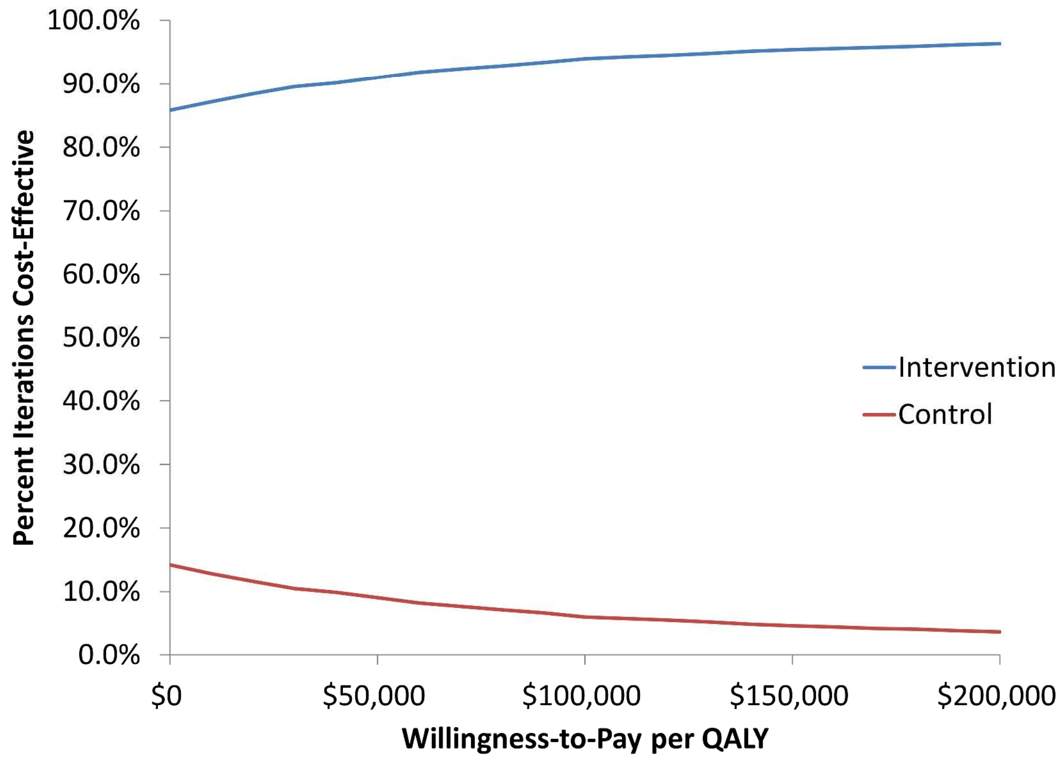
NH residents having septicemia as a principal diagnosis and secondary diagnosis of UTI and we have 5.3% with a primary diagnosis of UTI. This would give us a split of 52% of UTIs having a primary diagnosis of septicemia and 48% of UTIs having a primary diagnosis of UTI. Since this calculation involves a number of assumptions, we use a round 50% of all UTIs having a primary diagnosis of septicemia.

Supplementary Figure S1. Sensitivity on Rate of Hospitalization



The graph above shows the relationship between the rate of hospitalization per 1000 device-days under the TIP intervention for the case of a representative NH. The blue line represents health care system cost savings from the TIP intervention and negative values means that the TIP intervention is more costly. The rate of hospitalization under the control is 3.7 per 1000 device-days.

Supplementary Figure S2. Cost Effectiveness Acceptability Curves



Cost-effectiveness acceptability curve for a representative nursing home. The blue line represents percentage of iterations cost-effective at intervention sites; the red line represents percentage of iterations cost-effective at control sites. When varying all parameters simultaneously across plausible distributions, the TIP intervention is highly likely to be cost-effective.

Supplementary Table S1: Sensitivity to Parameters

	Cost savings when the parameter value is at the…	
	Min	**Max**
Parameter:		
Intervention Effectiveness		
Percent of residents with catheter	$25,872	$42,202
Clinically defined CAUTI per 1000 device days*		
Control	$25,699	$44,888
Intervention	$40,050	$25,699
Hospitalizations per 1000 device days*		
Control	($5,163)	$90,173
Intervention	$63,964	($10,524)
Intervention Cost Parameters		
FTE's required	$36,329	$31,746
Infection Control Annual fully-loaded salary	$37,683	$32,475
Educational Activities		
Nurses Hourly Wages	$35,524	$32,609
Nurses Hours for intervention	$34,171	$33,904
NA Hourly Wage	$34,188	$33,889
NA Hours for Intervention	$34,187	$33,887
Additional Resident Time		

Gown and Glove Donning Time (minutes) per Resident Visit for Intimate Activities of Daily Living (with Indwelling Device)	$37,121	$30,954
Resident Visits for Intimate Activities of Daily Living per Day	$35,813	$32,262
Supplies	$34,537	$33,537
Printing	$34,128	$33,947
Costs of Disease		
Cost of CAUTI in Nursing Home	$31,910	$36,246
Cost of Hospitalization		
Cost of Hospitalization due to CAUTI	$31,439	$36,637
Cost of Hospitalization from Septicemia	$26,842	$41,234
Fraction of CAUTI leading to septicemia	$24,844	$43,231
Utilities		
Length of CAUTI symptoms	$34,037	$34,037
Utility loss per CAUTI	$34,037	$34,037
Long term utility loss due to CAUTI	$34,037	$34,037

FTE: full-time equivalent
NH: nursing home
CAUTI: catheter-associated urinary tract infections
* Rates are per 1000 days a catheter device is inserted in a resident

Supplementary Table S2: CHEERS Checklist

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	Title mentions "Economic Evaluation" and abstract mentions "Cost-Effectiveness Analysis"
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	Abstract (page 3)
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study.	Page 5
		Present the study question and its relevance for health policy or practice decisions.	Page 4
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	Page 7
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	Pages 7-8
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	Pages 7-8

Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	Page 7
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	Page 7
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	n/a (analysis is one year)
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	Page 7
Measurement of effectiveness	11a	*Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	Page 7
	11b	*Synthesis-based estimates:* Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	n/a
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	Page 9
Estimating resources and costs	13a	*Single study-based economic evaluation:* Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Pages 8-9 and supplemental information page 1-3
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Pages 8-9

Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	Page 8
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended.	Page 7 and Figure 1
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	Page 7 and Supplemental text
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	Pages 7-10, Table 1 and Supplemental text
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	Page 10, Table 1, and Supplemental text.
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	Table 2
Characterising uncertainty	20a	*Single study-based economic evaluation:* Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective).	

	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	Pages 10-12, Figure 2, Supplemental figures
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	n/a
Discussion			
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	Pages 13-16
Other			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	Page 17
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	Page 17

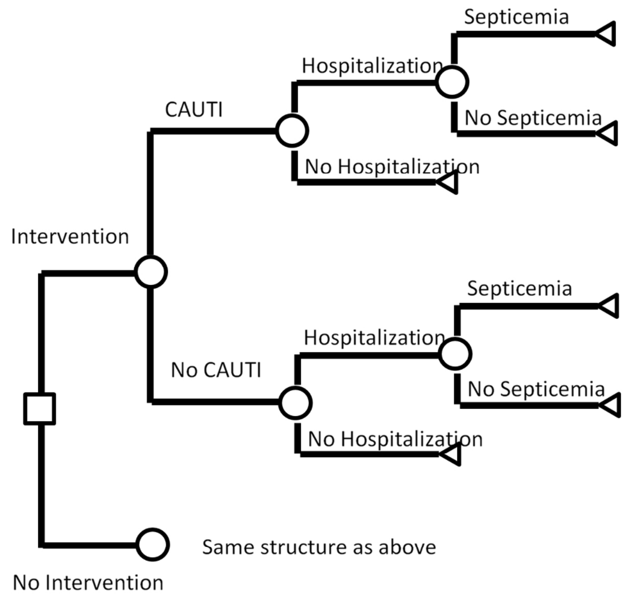


Figure 1. Schematic of decision tree model. The figure should be read from left to right. The square represents the intervention decision. Circles represent uncertain outcomes for nursing home residents: whether they get a catheter-associated urinary tract infection (CAUTI), whether they are hospitalized, and whether they have septicemia, given hospitalization.