Skip all front matter: Jump to Page 1

Research Report

Small Ideas for Saving Big Health Care Dollars

Technical Appendix

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Small Ideas for Saving Big Health Care Dollars: Technical Appendix

This appendix describes how each new cost savings estimate was generated. Unless otherwise noted, all *dollar* values reported here are adjusted to 2012 U.S. dollars using the Consumer Price Index medical care group for all urban consumers (U.S. Bureau of Labor Statistics*,* 2013). The net savings model, source data, model inputs and assumptions, and the annual savings estimates are provided for the following ideas:

- Shift care from emergency departments (EDs) to retail clinics where appropriate
- Prevent three types of health care–associated infections (HAIs):
  - central line–associated bloodstream infections
  - ventilator-associated pneumonia
  - catheter-associated urinary catheter infections
- Use preoperative and anesthesia checklists to prevent operative and postoperative events
- Prevent pressure ulcers
- Use ultrasound guidance for central line placement.

The net savings estimates are static estimates that reflect what could have happened if the recommended practice had been implemented nationally in the past year. A limitation to our approach is that we do not incorporate potential behavioral responses to the recommended practices for each idea. In other words, the estimates are potential savings under the assumption that the ideas are fully implemented. The implementation feasibility of each idea is assessed in the full report. The perspective of these analyses is the health care system, including payers, hospitals, and patients; only direct health care costs and monetary benefits are considered here. The estimated savings are to the health care system; we do not make any assumptions about who accrues the savings.

Shift Care from Emergency Departments to Retail Clinics Where Appropriate

Retail clinics are currently on the rise across the United States (Weinick, Burns, and Mehrotra, 2010). These medical offices are located in nontraditional care settings, such as pharmacies or grocery stores, and provide a range of preventive care services, as well as treatment for simple acute conditions. Many high-cost emergency department (ED) visits are treatable at alternative care settings, such as retail clinics. Policies, such as tax incentives, can encourage retail stores to open new clinics, while health literacy campaigns that communicate appropriate care settings for different symptoms or other similar interventions can encourage the utilization of existing retail clinics. The savings estimate presented below does not include the cost of any interventions because of the lack of data availability and the difficult nature of estimating these costs accurately.

The national cost savings for increased retail clinic use is estimated by multiplying the number of ED visits a year in the United States that can be treated in non-ED environments by the percentage of those visits that can be appropriately treated at retail clinics during hours of operation and by the average difference in treatment cost between retail clinics and ED per episode. Our savings estimate is based on the 2010 Weinick, Burns, and Mehrotra study that examined the cost savings of shifting a percentage of ED visits to urgent care centers and retail clinics. Two assumptions of this study are that all patients who could be treated at retail clinics would correctly shift from EDs and that existing retail clinics had the capacity to provide care to these new patients. Other cost estimates that indicate savings between retail clinics and more traditional outpatient office settings for various populations exist, but they are not included in the below estimate (Mehrotra et al., 2009; Thygeson et al., 2008). It is still unknown whether these cost savings would remain if patients previously receiving no health care began to receive care in these lower-cost settings. However, improvements in access to care that are due to retail clinic services could provide benefits to overall patient health.

Model

Net savings = number of ED visits a year in the United States that can be treated in non-ED environments
× percentage of those visits that can be appropriately treated at retail clinics
× average difference in treatment cost between retail clinics and ED per case.

Source Data

Parameter	Value	Year	References
Number of ED visits a year in the United States	129,843,000	2010	National Hospital Ambulatory Medical Care Survey, 2010
Percentage of visits that could be treated at retail clinics	7.9%	2010	Weinick, Burns and Mehrotra, 2010
Difference in treatment cost between retail clinics and EDs per case	$279–$460	2010	Weinick, Burns and Mehrotra, 2010

Model Input Assumptions

	Model Inputs		
Parameter	**Lower Bound**	**Base Case**	**Upper Bound**
Number of ED visits a year in the United States that can be treated in non-ED environments	112,963,410		
Percentage of visits that could be treated at retail clinics	4.0%	7.9%	7.9%
Difference in treatment costs between retail clinics and EDs per case	$298	$395	$491

NOTE: Dollar amounts are in 2012 U.S. dollars.

Number of ED visits a year in the U.S. that can be treated in non-ED environments:

- The number of ED visits a year that can be treated in non-ED environments is assumed to be 112,963,410. This estimate is constructed by taking the number of total ED visits in 2010 (129,843,000) and excluding 13 percent of these visits. This is the percentage that Weinick, Burns, and Mehrotra (2010) determined de facto could only be treated in ED environments from the 2006 dataset. It is assumed that this percentage is constant across years.

Percentage of visits that could be treated at retail clinics:

- Base case and upper bound: The percentage of visits treatable at retail clinics is assumed to be 7.9 percent and is taken from Weinick, Burns, and Mehrotra (2010). This estimate is based on the percentage of visits treatable at retail clinics out of the total visits to the

ED that did not have to be treated in ED environments. The calculated parameter considers the hours of operation for retail clinics. Weinick, Burns, and Mehrotra (2010) estimates that 13.7 percent of total ED visits could be treated at retail clinics if hours of operation are not restricted. It is assumed that all patients that could be treated at retail clinics will correctly shift from EDs and also that existing retail clinics have the necessary capacity to handle the increased demand. Because of these limitations, we recognize that the base case estimate may be an upper-bound estimate on the percentage of incidents that would actually be treated at retail clinics.

- Lower bound: As the 7.9 percent reflects the assumption that all patients would correctly shift from EDs, we assumed the percentage of incidents treatable at retail clinics to be roughly half of this value (4%) in the lower-bound scenario.

Difference in treatment costs between retail clinics and EDs per case:

- The range of cost savings of treatment at retail clinics compared to EDs is taken from Weinick, Burns, and Mehrotra (2010) and is based on research by Thygeson et al. (2008) and Mehrotra et al. (2009). It is assumed that the numbers provided by Weinick, Burns, and Mehrotra (2010) are in 2010 U.S. dollars. The cost difference between these settings may be due to higher-priced labor in the ED or other fixed costs of the ED. However, it is possible that if the demand structure for EDs changes, there could also be a reduction in ED capacity and the fixed costs.
- Base case: The cost savings per case of treatment in retail clinics compared to EDs is assumed to be the midpoint parameter value of $370 (2010 U.S. dollars).
- Lower bound: The cost savings per case of treatment in retail clinics is assumed to be the lower-bound parameter value of $279 (2010 U.S. dollars).
- Upper bound: The cost savings per case of treatment in retail clinics is assumed to be the upper-bound parameter value of $460 (2010 U.S. dollars).

Savings Estimates

	Annual Estimate ($ in millions)		
	Lower Bound	**Base Case**	**Upper Bound**
Net savings	$1,240	$3,525	$4,382

NOTE: Estimates are in millions of dollars and are adjusted to 2012 U.S. dollars.

Limitations

The cost estimates provided here are based on the methodology developed by Weinick, Burns, and Mehrotra (2010). In our base case scenario, we assumed that all patients who could be appropriately treated at retail clinics would correctly shift their point of care to a retail clinic and that patients who needed to be treated in an ED setting would correctly select their point of care as well. We also assumed that there was enough capacity at the retail clinics to meet this increased demand. These assumptions are limitations and may contribute to an overestimation of the cost savings associated with shifting care to retail clinics. However, Weinick, Burns, and Mehrotra (2010) also assumed that the full range of services that could be provided at retail clinics was captured. This may underestimate the potential savings and might counter the effect of the previous assumptions.

Our estimate also does not account for any intervention costs associated with educating patients about appropriate sites of treatment or other policies that may incentivize the creation of new retail clinics. This is a large limitation of the cost savings estimate; thus, the net savings range may be an overestimate of the true range of savings associated with retail clinics.

Prevent Health Care–Associated Infections

The three health care–associated infection (HAI) prevention ideas are based on recommended practices from a patient safety evidence report prepared by the Southern California Evidence-Based Practice Center (Shekelle et al., 2013). Bundles of central line–associated bloodstream infection (CLABSI) practices recommended by the Centers for Disease Control and Prevention (CDC) include hand hygiene, catheter kits, maximal sterile barrier precautions, chlorhexidine for skin antisepsis, antimicrobial catheters, subclavian vein insertion, disinfecting hubs, removal of nonessential central venous catheters, chlorhexidine cleansing and sponges, topical antibiotic use, antibiotic or anti-infective "locks," systemic antibiotic prophylaxis, educational programs, checklists, and specialized central venous catheter insertion teams. Bundled interventions for ventilator-associated pneumonia (VAP) include head-of-bed elevation, sedation vacations, oral care with chlorhexidine, and subglottic suctioning endotracheal tubes. Catheter-associated urinary tract infection (CAUTI) bundles include catheter reminders, stop orders, and nurse-initiated removal protocols to reduce use and encourage timely removal of indwelling urinary catheters.

The cost savings estimates were calculated as the savings from averted infections and the expected infection treatment costs minus the cost of bundled interventions, consisting of recommended prevention practices, equipment and supplies, and education and training. Hospital cost parameters and infection rates are from the Healthcare Cost and Utilization Project (HCUP) and CDC surveillance reports (HCUPnet, 2011; Malpiedi et al., 2013; Scott, 2009). The reductions in infections that are due to infection prevention practices are based on summaries or meta-analyses of published studies (Meddings et al., 2010; Umscheid et al., 2011). The proportions of hospitals using key infection prevention practices are based on a 2009 survey of prevention practices (Krein et al., 2012). However, we recognize that infection prevention practices are becoming more widespread because of increased recognition of preventable HAIs and Centers for Medicare & Medicaid Services (CMS) payment changes for certain hospital-acquired conditions beginning in 2008. Given the changing landscape of more widespread infection prevention practices and the corresponding decrease in infection rates, estimating the current cost of infections is challenging. In addition, limited data on the cost of bundled interventions containing multiple prevention practices are available; thus, intervention costs of bundled interventions are based on only one or two studies (Clarke et al., 2013; Saint et al., 2005; Waters et al., 2011). The estimated intervention cost of CLABSI and VAP bundled interventions is based on a single study of six hospitals that included both CLABSI and VAP prevention practices. The estimated cost of CAUTI bundled interventions is based on two single-hospital studies. Due to the limited availability of intervention cost data, the available intervention costs per hospital were assumed to be representative of mean intervention costs and were scaled to the national level based on the number of U.S. hospitals reported by the American Hospital Association (AHA) (AHA, 2013).

Central Line–Associated Bloodstream Infection (CLABSI)

Model

Net savings = benefits – costs

= savings from averted CLABSIs – CLABSI prevention intervention costs

= (mean treatment cost per CLABSI × number of CLABSIs × percentage of CLABSI reduction with prevention interventions)

– (mean CLABSI intervention cost per hospital × number of hospitals × percentage of hospitals not using key CLABSI prevention practices)

Source Data

Parameter	**Value**	**Year**	**Reference**
Mean hospital costs per CLABSI principal diagnosis	$19,751	2011	HCUPnet, 2011
Mean attributable costs per CLABSI	$5,734–$22,939	2003	Scott, 2009; Hu et al., 2004
Annual number of discharges with CLABSI - principal diagnosis - all-listed diagnosis	 8,014 13,023	2011	HCUPnet, 2011
Annual number of CLABSIs in 3,468 facilities reporting to the National Healthcare Safety Network (NHSN)	18,113	2011	Malpiedi et al., 2013
Percentage of CLABSI reduction with bundled interventions in intensive care units (ICUs)	45% (range 18%–66%)	2000–2006	Umscheid et al., 2011
Mean annual intervention cost per hospital for CLABSI + VAP prevention bundles	$161,584	2010	Waters et al., 2011
Annual number of VAP all-listed diagnosis discharges	22,741	2011	HCUPnet, 2011
Number of U.S. hospitals, excluding nonfederal psychiatric hospitals	5,303	2011	AHA, 2013

Parameter	Value	Year	Reference
Percentage of hospitals using - maximum barrier precautions - chlorhexidine site antisepsis - antimicrobial dressing - antimicrobial catheters	 91.0% 95.8% 57.5% 31.8%	2009	Krein et al., 2012
Percentage reduction in CLABSIs from 2008 to 2011 based on NHSN data	41%	2011	Malpiedi et al., 2013

NOTE: CLABSI and VAP diagnoses were identified by ICD-9-CM codes 999.32 and 997.31, respectively, in 2011 HCUP data.

Model Input Assumptions

	Model Inputs		
Parameter	**Lower Bound**	**Base Case**	**Upper Bound**
Mean treatment cost per CLABSI	$14,015	$17,990	$17,990
Annual number of CLABSIs	13,023	13,023	27,697
Mean percentage of CLABSI reduction with bundled interventions	18%	18%	45%
Mean annual intervention cost per hospital for CLABSI + VAP prevention bundles		$172,603	
Proportion of CLABSI to CLABSI + VAP cases	56.8%	36.4%	36.4%
Number of U.S. hospitals		5,303	
Percentage of hospitals not using key CLABSI practices	7.2%	7.2%	17.4%

NOTE: Dollar amounts are in 2012 U.S. dollars.

Mean treatment cost per CLABSI:

- Base case and upper bound: The mean treatment cost per case is calculated as the weighted sum of principal diagnoses and nonprincipal diagnoses ($17,990). This value was used for the base case because it incorporates the cost of principal diagnoses. The same value was also used in the upper-bound case because we did not find additional data to justify a higher treatment cost per CLABSI.

   - The mean treatment cost per principal diagnosis is $20,475, which is the 2012 adjusted amount based on HCUP data. The mean cost per nonprincipal diagnosis is taken as the first quartile of the range of mean attributable costs per case ($14,015 in 2012 U.S. dollars, adjusted from the values in Scott [2009]). The first quartile, rather than the mean, of this range was selected because the entire range includes both principal and nonprincipal diagnoses; nonprincipal diagnoses account for 38 percent of total diagnoses.
   - The number of nonprincipal diagnoses is the difference between all-listed diagnoses and principal diagnoses from HCUP data (13,023 – 8,014 = 5,009).
- Lower bound: The mean treatment cost per case is the first quartile of the range of mean attributable costs per case ($14,015 in 2012 U.S. dollars, from Scott [2009]).

Annual number of CLABSIs:

- Base case and lower bound: The number of cases is equal to the number of HCUP all-listed diagnoses (13,023). In the base case, the principal diagnoses (8,014) are taken as a subset of all-listed diagnoses. Principal diagnoses were not considered as having separate costs in the lower-bound case.
- Upper bound: The number of cases is the number reported to the NHSN and scaled to the national level (27,697 cases in 5,303 U.S. hospitals based on Malpiedi et al. [2013]).

Percentage reduction in CLABSI from bundled interventions:

- Base case and lower bound: The percentage reduction is assumed to be the lowest reported percentage reduction among the seven studies included in Umscheid et al. (2011) (18%). The lowest value was selected for both the base case and lower bound after consideration of current widespread use of CLABSI prevention practices and that the CLABSIs still occurring may be more difficult to prevent. Although CLABSI reduction in non-ICU settings may be different from ICUs, the percentage reduction in other hospital units had not been demonstrated, and we assume that the percentage reduction in other units would be similar to the observed reduction in ICUs.
- Upper bound: The percentage reduction is assumed to be the mean reduction from the seven studies included in Umscheid et al. (2011) (45%).

Mean CLABSI + VAP intervention cost per hospital:

- Because information on the cost of a CLABSI-specific intervention was not available, the CLABSI intervention cost is based on the costs of a six-hospital patient safety program by Waters et al. (2011) that included both CLABSI and VAP interventions ($172,603 in 2012 U.S. dollars). The proportion of CLABSI + VAP intervention cost attributed to CLABSI prevention is assumed to be equal to the ratio of CLABSI cases to CLABSI + VAP cases.

- Mean CLABSI intervention cost per hospital = mean CLABSI + VAP intervention cost per hospital × (CLABSI cases / CLABSI + VAP cases)

Proportion of CLABSI cases to CLABSI + VAP cases:

- Base case and upper bound: The proportion of cases is based on 13,023 CLABSI and 22,741 VAP all-listed diagnoses in HCUP data (36.4% of CLABSI + VAP intervention cost attributed to CLABSI prevention). This value was used for the base case because it is the lower estimate of the intervention cost of CLABSI practices based on available incidence data. The same value was also used in the upper-bound case because we did not find additional data to justify a lower cost.
- Lower bound: The proportion of cases is based on 29,896 CLABSI cases from NHSN surveillance and 22,741 VAP all-listed diagnoses in HCUP data (56.8% of CLABSI + VAP intervention cost attributed to CLABSI prevention). This value was used for the lower bound estimate because it is a high estimate of the intervention cost of CLABSI practices based on available incidence data.

Number of U.S. hospitals:

- The number of hospitals, excluding nonfederal psychiatric hospitals, reported by the AHA in 2011 was 5,303. We assumed that the number has been constant since 2011 because these are the most recent AHA data available.

Percentage of hospitals not using key CLABSI practices:

- The estimated prevalence of CLABSI prevention practices is based on the use of four practices in 2009 (maximum barrier precautions, chlorhexidine site antisepsis, antimicrobial dressing, and antimicrobial catheters) equally weighted and the assumption that the increase in the use of these practices corresponds to the estimated decrease in CLABSIs from 2009 to 2012.
    - The percentages of nonfederal and VA hospitals using key CLABSI prevention practices in the Krein et al. (2012) survey were weighted by the number of hospitals surveyed (600 nonfederal and 119 VA hospitals) and assumed to be nationally representative.
    - Base case and lower bound: The percentage increase in the use of these practices is assumed to correspond with the 41-percent reduction in CLABSIs from 2008 to 2011 as reported in the NHSN data. The reduction in CLABSIs is largely due to the increase in initiatives to prevent HAIs, such as the On the CUSP: Stop BSI initiative funded by the Agency for Healthcare Research and Quality (On the CUSP: Stop HAI, 2013).

- Upper bound: The percentage increase in the use of these practices is assumed to be 20.5 percent, accounting for half of the incidence reduction from 2008 to 2011.

Savings Estimates

	Annual Estimate ($ in millions)		
	Lower Bound	**Base Case**	**Upper Bound**
Benefits: Savings from averted CLABSIs	32.9	42.2	222.1
Costs: CLABSI prevention intervention costs	87.6	23.9	23.9
Net savings	**–54.7**	**18.3**	**198.2**

Note: Estimates are in millions of dollars and are adjusted to 2012 U.S. dollars.

Ventilator-Associated Pneumonia (VAP)

Model

Net savings = benefits – costs
= savings from averted VAPs – VAP prevention intervention costs
= (mean treatment cost per VAP × number of VAP cases × percentage of VAP reduction with prevention intervention)
– (mean VAP intervention cost per hospital × number of hospitals × percentage of hospitals not using key VAP practices)

Source Data

Parameter	**Value**	**Year**	**References**
Mean attributable costs per VAP case	\$11,897–\$25,072	1999, 2005	Scott, 2009; Warren et al., 2003; Anderson et al., 2007
Annual number of discharges with VAP - principal diagnosis - all-listed diagnosis	 1,625 22,741	2011	HCUPnet, 2011
Percentage of VAP reduction with bundled interventions in ICUs	47% (range 38%–55%)	2004, 2006	Umscheid et al., 2011
Mean annual intervention costs per hospital for CLABSI + VAP prevention bundles	\$161,584	2010	Waters et al., 2011
Annual number of CLABSI all-listed diagnosis discharges	13,023	2011	HCUPnet, 2011
Annual number of CLABSIs in 3,468 facilities reporting to the NHSN	18,113	2011	Malpiedi et al., 2013
Number of U.S. hospitals, excluding nonfederal psychiatric hospitals	5,303	2011	AHA, 2013

Parameter	Value	Year	References
Percentage of hospitals using - semirecumbent positioning - antimicrobial mouth rinse - subglottic secretion drainage - selective digestive tract decontamination	 95.5% 58.3% 41.2% 22.3%	2009	Krein et al., 2012
Percentage reduction in CAUTIs from 2009 to 2011, based on NHSN data	7%	2011	Malpiedi et al., 2013

NOTE: CLABSI and VAP diagnoses were identified by ICD-9-CM codes 999.32 and 997.31, respectively, in 2011 HCUP data.

Model Input Assumptions

	Model Inputs		
Parameter	Lower Bound	Base Case	Upper Bound
Mean treatment cost per VAP		$25,943	
Annual number of VAP cases		22,741	
Mean percentage of VAP reduction with bundled interventions	38%	47%	47%
Mean intervention cost per hospital for CLABSI + VAP prevention bundles		$172,603	
Proportion of VAP cases to CLABSI + VAP cases	63.6%	63.6%	46.2%
Number of U.S. hospitals		5,303	
Percentage of hospitals not using key VAP practices		39.3%	

NOTE: Dollar amounts are in 2012 U.S. dollars.

Mean treatment cost per VAP case:

- The mean treatment cost per case is calculated as the midpoint of the range of mean attributable costs per case ($25,943 in 2012 U.S. dollars, adjusted from the values in Scott [2009]).
    - The mean of this range was selected because nonprincipal diagnoses account for 93 percent of total diagnoses, which means that the midpoint value is

similar to the weighted sum of principal diagnoses and nonprincipal diagnoses ($24,725 in 2012 U.S. dollars). The number of nonprincipal diagnoses is taken as the difference between all-listed diagnoses and principal diagnoses from HCUP data (22,741 – 1,625 = 21,116). For reference, the mean cost per principal diagnosis in 2012 U.S. dollars is $33,629, which is the 2012 adjusted amount based on HCUP data.

Annual number of VAP cases:

- The number of cases is equal to the number of HCUP all-listed diagnoses (22,741).

Percentage reduction in VAP from bundled interventions:

- Base case and upper bound: The percentage reduction is assumed to be the mean percentage reduction of the four studies included in Umscheid et al. (2011) (47%). The mean reduction was also used for the upper-bound estimate because we do not expect the nationwide reduction in VAP to exceed the average reduction demonstrated in research studies. Although VAP reduction in non-ICU settings may be different from ICUs, the percentage reduction in other hospital units had not been demonstrated and we assume that the percentage reduction in other units would be similar to the observed reduction in ICUs.
- Lower bound: The percentage reduction is assumed to be lowest reported percentage reduction among the four studies included in Umscheid et al. (2011) (38%).

Mean CLABSI + VAP intervention cost per hospital:

- As information on the cost of a VAP-specific intervention was not available, the VAP intervention cost is based on the costs of a six-hospital patient safety program conducted by Waters et al. (2011) that included both CLABSI and VAP prevention interventions. The proportion of CLABSI + VAP intervention cost attributed to VAP prevention is assumed to be equal to the ratio of VAP cases to CLABSI + VAP cases.
    - Mean VAP intervention cost per hospital = mean CLABSI + VAP intervention cost per hospital × (VAP cases / CLABSI + VAP cases)

Proportion of VAP cases to CLABSI + VAP cases:

- Base case and lower bound: The proportion of cases is based on 22,741 VAP and 13,023 CLABSI all-listed diagnoses in HCUP data (63.6% of CLABSI + VAP intervention cost attributed to VAP prevention). This value was also used for the lower bound estimate because it is a high estimate of the intervention cost of VAP practices based on available CLABSI and VAP incidence data.
- Upper bound: The proportion of cases is based on 22,741 VAP all-listed diagnoses from HCUP and 27,697 CLABSI cases from NHSN surveillance (46.2% of CLABSI + VAP intervention cost attributed to VAP prevention).

Number of U.S. hospitals:

- The number of hospitals, excluding nonfederal psychiatric hospitals, reported by the AHA in 2011 was 5,303. We assumed that the number has been constant since 2011 because these are the most recent AHA data available.

Percentage of hospitals not using key VAP practices:

- The estimated prevalence of VAP prevention practices is based on the use of four practices in 2009 (semirecumbent positioning, antimicrobial mouth rinse, subglottic secretion drainage, and selective digestive tract decontamination) equally weighted and the assumption that the increase in the use of these practices corresponds to the estimated decrease in VAPs from 2009 to 2012.
    - The percentages of nonfederal and VA hospitals using key VAP prevention practices in Krein et al. (2012) were weighted by the number of hospitals surveyed (600 nonfederal and 119 VA hospitals) and assumed to be nationally representative.
    - The percentage reduction in VAP is unclear; however, large-scale HAI initiatives have focused more on CLABSI rather than CAUTI and VAP. Thus, the percentage increase in the use of VAP practices is assumed to be similar to the 7-percent reduction in CAUTIs from 2009 to 2011, as reported to the NHSN.

Savings Estimates

	Annual Estimate ($ in millions)		
	Lower Bound	**Base Case**	**Upper Bound**
Benefits: Savings from averted VAPs	224.2	275.8	275.8
Costs: VAP prevention intervention costs	228.7	228.7	162.1
Net savings	**–4.5**	**47.1**	**113.7**

NOTE: Estimates are in millions of dollars and are adjusted to 2012 U.S. dollars.

Catheter-Associated Urinary Tract Infection (CAUTI)

Model

Net savings = benefits – costs

= savings from averted CAUTIs – CAUTI prevention intervention costs

= (mean treatment cost per CAUTI × number of CAUTI cases × percentage of CAUTI reduction with prevention intervention)

– (mean CAUTI intervention cost per hospital × number of hospitals × percentage of hospitals not using key CAUTI practices)

Source Data

Parameter	**Value**	**Year**	**References**
Mean hospital costs per CAUTI principal diagnosis	$9,881	2011	HCUPnet, 2011
Mean attributable costs per CAUTI	$589–$758	1998, 2002	Anderson et al., 2007; Scott, 2009; Tambyah, Knasinski, and Maki, 2002
Mean treatment cost per uncomplicated CAUTI case	$676	1998	Saint, 2000
Mean treatment cost per CAUTI with bacteremia complication	$2,836	1998	Saint, 2000
Proportion of CAUTIs with bacteremia complication	0.036	1998	Saint, 2000
Annual number of discharges with CAUTI - principal diagnosis - all-listed diagnosis discharges	 43,598 82,612	2011	HCUPnet, 2011
Percentage of CAUTI reduction with reminder or stop order interventions	52% (range 28%–85%)	2010	Meddings et al., 2010

Parameter	Value	Year	References
Mean annual intervention cost per hospital for CAUTI prevention bundles, including silver alloy catheters, securing devices after catheter insertion, reposition catheter tubing, and electronic reminders for the removal of catheters	$23,924	2010	Clarke et al., 2013
Mean annual intervention cost per hospital for CAUTI prevention bundles, including reminders	$53,200	2005	Saint et al., 2005
Number of U.S. hospitals, excluding nonfederal psychiatric hospitals	5,303	2011	AHA, 2013
Percentage of hospitals using - bladder ultrasounds - reminders or stop orders - antimicrobial urinary catheters - condom catheters	 44.1% 19.8% 41.2% 16.5%	2009	Krein et al., 2012
Percentage reduction in CAUTIs from 2009 to 2011, based on NHSN data	7%	2011	Malpiedi et al., 2013

NOTE: CAUTI diagnoses were identified by ICD-9-CM code 999.64 in 2011 HCUP data.

Model Input Assumptions

	Model Inputs		
Parameter	**Lower Bound**	**Base Case**	**Upper Bound**
Mean treatment cost per CAUTI		$5,984	
Annual number of CAUTI cases		82,612	
Mean percentage of CAUTI reduction with intervention	18%	52%	52%
Mean CAUTI intervention cost per hospital	$68,298	$46,927	$25,555
Number of U.S. hospitals		5,303	
Percentage of hospitals not using key CAUTI practices		62.6%	

NOTE: Dollar amounts are in 2012 U.S. dollars.

Mean treatment cost per CAUTI:

- The mean treatment cost per case is calculated as the weighted sum of principal diagnosis and nonprincipal diagnosis costs ($5,984 in 2012 U.S. dollars).
  - The mean treatment cost per principal diagnosis in 2012 U.S. dollars is $10,253, based on HCUP data. The mean treatment cost per nonprincipal diagnosis is taken as the weighted sum of the cost of CAUTI complicated by bacteremia and the mean cost of uncomplicated CAUTI from three studies ($1,225 in 2012 U.S. dollars, adjusted from the values report by Scott [2009] and Saint [2000]).
  - The number of nonprincipal diagnoses is the difference between all-listed diagnoses and principal diagnoses from HCUP data (82,612 – 43,598 = 39,014).

Annual number of cases:

- The number of cases is based on HCUP all-listed diagnoses (82,612) and assumed that the principal diagnoses (43,598) are a subset of all-listed diagnoses.

Percentage reduction of CAUTI from bundled interventions:

- Base case and upper bound: The mean percentage reduction is a pooled estimate of the reduction in CAUTI rate from the Meddings et al. (2010) meta-analysis of seven studies using reminders or stop orders (52%). The mean reduction was also used for the upper bound estimate because we do not expect nationwide reduction in CAUTIs to exceed the pooled estimate of reduction demonstrated in research studies.
- Lower bound: The mean percentage reduction is the lowest estimate of CAUTI reduction from the Meddings et al. (2010) meta-analysis of seven studies (28%).

Mean CAUTI intervention cost per hospital:

- Base case: The mean CAUTI prevention intervention cost is taken as the mean of intervention cost from two single-hospital interventions ($46,927 in 2012 U.S. dollars, adjusted from the costs reported by Clarke et al. [2013] and Saint et al. [2005]).
- Lower bound: The mean CAUTI prevention intervention cost is assumed to be the higher intervention cost among the two available studies ($68,298 in 2012 U.S dollars, adjusted from the cost reported by Saint et al. [2005]).
- Upper bound: The mean CAUTI prevention intervention cost is assumed to be the lower intervention cost among the two available studies ($25,555 in 2012 U.S. dollars, adjusted from the values reported by Clarke et al. [2013]).

Number of U.S. hospitals:

- The number of hospitals, excluding nonfederal psychiatric hospitals, reported by the AHA in 2011 was 5,303. We assumed that the number has been constant since 2011 because these are the most recent AHA data available.

Percentage of hospitals not using key CAUTI practices:

- The estimated prevalence of CAUTI prevention practices is based on the use of four practices (bladder ultrasounds, reminders or stop orders, antimicrobial urinary catheters, and condom catheters) equally weighted and the assumption that the increase in the use of these practices corresponds to the estimated decrease in CAUTIs from 2009 to 2012.
  - The percentages of nonfederal and VA hospitals using key CAUTI prevention practices in Krein et al. (2012) were weighted by the number of hospitals surveyed (600 nonfederal and 119 VA hospitals) and assumed to be nationally representative.
  - The percentage increase in the use of these practices is assumed to approximately correspond with the 7-percent reduction in CAUTIs from 2009 to 2011, as reported in the NHSN data.

Savings Estimates

	Annual Estimate ($ in millions)		
	Lower Bound	**Base Case**	**Upper Bound**
Benefits: Savings from averted CAUTIs	138.4	257.1	257.1
Costs: CAUTI prevention intervention costs	226.7	155.8	84.8
Net savings	**–88.3**	**101.3**	**172.2**

NOTE: Estimates are in millions of dollars and are adjusted to 2012 U.S. dollars.

Limitations

A limitation of the HAI cost analyses is that the current parameter values are difficult to estimate because of an ongoing increase in uptake of infection prevention practices and the corresponding decrease in number of infections. The assumption that the use of prevention practices correspond to the reduction in infection rates may not reflect the true use of prevention practices. Because of the lack of data on other intervention costs, another limitation is that the estimated cost of bundled interventions is based on one or two studies, which we assume are generalizable to other settings in the United States

The ranges of our net savings estimates are wide because of uncertainty in some of the model inputs. The negative lower bound estimate means that the intervention costs may be larger than the savings from averted infections—i.e., the possibility of a net cost given the uncertainty in our parameters. However, in all three HAI cases, our best estimate in the base case reflects a positive net savings. In addition, we are only considering monetary benefits to the health care system (including payers and patients)—that is, indirect benefits, such as improvements to overall patient health and quality of life and reduced sick days and lost wages, are not included in the benefits. Even though the possibility of a net cost exists for these practices, infection prevention practices are strongly encouraged by evidence-based reviews (Shekelle et al., 2013a; Shekelle et al., 2013b), there have been nationwide initiatives to reduce HAIs (On the CUSP: Stop HAI, 2013), and the prevention of HAIs is likely cost-effective.

Preoperative and Anesthesia Checklists to Prevent Operative and Postoperative Events

The use of checklists has been shown to reduce surgical errors and complications (Shekelle et al. 2013; Gawande; 2010). The World Health Organization Surgical Safety Checklist is an example of a checklist containing both preoperative and anesthesia items and has been adopted by hospitals worldwide (World Health Organization, 2013). Although strong evidence of the effectiveness of checklists exists, only about 25 percent of U.S. hospitals are estimated to use surgical checklists (Clark, 2011; Feldscher, 2013; Joelving, 2011). The national cost savings estimates presented here are based on a cost-benefit analysis of a single institution by Semel et al. (2010). The challenges in checklist use are in the implementation of the checklist; thus, a key driver of uncertainty in these estimates is the relative reduction in complications that can be achieved by using checklists. While a reduction rate as high as 30 percent has been demonstrated, the base case scenario presented here assumes that not all institutions would be able to achieve such successful implementation.

Model

Net savings = benefits – costs
= savings from averted surgical complications – checklist intervention costs
= [(number of inpatient noncardiac operations per year × complication rate × cost per major complication × relative reduction in major complications with checklist)
– (checklist per-use cost × number of inpatient operations per year + checklist intervention cost per hospital × number of hospitals)] × proportion of hospitals not using checklists

Source Data

Parameter	Value	Year	References
Number of inpatient noncardiac surgeries	9,167,749	2011	HCUPnet, 2011
Baseline major complication rate	3% (range 1%–17%)	2008	Semel et al., 2010
Cost per major inpatient complication	$13,372 (range $6,686–$26,744)	2008	Semel et al., 2010

Parameter	Value	Year	References
Relative reduction in major complications with the checklist	10% (range 5%–30%)	2008	Semel et al., 2010
Checklist per-use cost	$11 (range $5.5–$22)	2008	Semel et al., 2010
Checklist intervention cost per institution	$12,635 (range $6,318–$25,270)	2008	Semel et al., 2010
Number of U.S. hospitals, excluding nonfederal psychiatric hospitals	5,303	2011	AHA, 2013
Estimated proportion of hospitals using surgical checklists	25%	2011	Clark, 2011; Feldscher, 2013; Joelving, 2011

Model Input Assumptions

	Model Inputs		
Parameter	**Lower Bound**	**Base Case**	**Upper Bound**
Number of inpatient surgeries		9,167,749	
Mean baseline major complication rate		3%	
Mean cost per major inpatient complication		$15,240	
Relative reduction in major complications with the checklist	5%	10%	30%
Mean checklist per-use cost	$25	$13	$13
Mean checklist intervention cost per hospital	$28,800	$14,440	$14,440
Number of U.S. hospitals		5,303	
Proportion of hospitals not already using checklists	60%	75%	90%

NOTE: Dollar amounts are in 2012 U.S. dollars.

Number of inpatient noncardiac surgeries:

- The number of inpatient noncardiac surgeries is taken from HCUP inpatient data and is assumed to be constant since 2011. Noncardiac surgeries were selected as all operating room principal procedures except operations on the cardiovascular system, as classified by the Clinical Classification Software.

Mean baseline major complication rate:

- The mean baseline major complication rate is assumed to be 3 percent. The 3-percent complication rate is adopted from the analysis by Semel et al. (2010), who based this parameter on a review of surgical procedures in Utah and Colorado. Without additional information on a nationwide estimate of major complications, we assumed that the national complication rate would be similar.

Mean cost per major inpatient complication:

- The mean cost per major inpatient complication is assumed to be $15,240 in 2012 U.S. dollars, adjusted from the amount used by Semel et al. (2010). This value is based on costs reported in the literature. We did not vary this parameter in the lower- and upper-bound cases because we assumed that this was a mean cost per complication that would reflect the expected national cost of inpatient complications.

Relative reduction in major complications with the checklist:

- The range of relative reduction in major complications with the checklist is based on the analysis by Semel et al. (2010). A 30-percent relative reduction in major complications has been observed in high-income sites during a checklist study, and this value is used as the upper-bound parameter. To account for the possibility of less-effective checklist implementation, Semel et al. assumed a 10-percent relative reduction in their base case analysis, and 5 percent as the lower bound for sensitivity analysis. We adopt the same range for the base case and lower-/upper-bound parameter values here.

Mean checklist per-use cost:

- The range of checklist per-use cost is also based on the analysis by Semel et al. (2010). For the base case and upper bound, we assumed the mean checklist per-use cost to be $13, which is the 2012 adjusted base case value used by Semel et al. To be conservative about checklist use costs, we chose not to use the lower cost value of $6 per use for the upper bound. For the lower bound, the mean checklist per-use cost is assumed to be the higher value used by Semel et al. ($25 in 2012 U.S. dollars).

Mean checklist intervention cost per hospital:

- The range of checklist intervention cost is based on the analysis by Semel et al. (2010). The base case and upper-bound mean checklist intervention costs per hospital values were assumed to be $14,440 in 2012 U.S. dollars. Again, we did not use the lower value reported by Semel et al. ($7,201 in 2012 U.S. dollars) because we assumed that, on average, the national intervention cost would be better reflected by the middle parameter value. To account for the possibility that average intervention costs may be higher than the base case value estimated by Semel et al., the mean checklist intervention cost per hospital is assumed to be $28,800 (2012 U.S. dollars) in the lower-bound case.

Number of U.S. hospitals:

- The number of hospitals, excluding nonfederal psychiatric hospitals, reported by the AHA in 2011 was 5,303. Because these are the most recent AHA data available, we assumed that the number has been constant since 2011.

Proportion of hospitals not using surgical checklists:

- The estimated proportion of hospitals not using surgical checklists is 75 percent, based on expert judgment. However, as there have not been any surveys on surgical checklist use, we varied this parameter estimate by assuming no surgical checklist use in 60 percent of hospitals for the lower-bound value and 90 percent of hospitals for the upper-bound value.

Savings Estimates

	Annual estimate ($ in millions)		
	Lower Bound	**Base Case**	**Upper Bound**
Benefits: Averted complications from checklist use	125.7	314.3	1,131.7
Costs: Checklist use and intervention costs	236.8	148.0	177.6
Net savings	**–111.1**	**166.3**	**954.1**

NOTE: Estimates are in millions of dollars and are adjusted to 2012 U.S. dollars.

Limitations

A limitation of the cost savings estimates for checklists to prevent operative and postoperative events is that the current prevalence of checklist use is unknown. The values used here are best guesses of the proportion of hospitals that use surgical checklists. Another limitation is that this analysis relies heavily on parameters from a single study in a Massachusetts hospital. The uncertainty in how these parameters would scale to the national level is reflected in the wide range of the final net savings estimate. One key driver in the uncertainty of the net savings estimate is the relative reduction of major complications from using the checklists. Although intervention studies have demonstrated reduction in complications of up to 30 percent, which we have used in the upper bound estimate, it is unknown how much reduction could be possible at the national level.

Prevent In-Facility Pressure Ulcers

The idea to prevent in-facility pressure ulcers (PUs) is based on recommended practices from a patient safety evidence report prepared by the Southern California Evidence-Based Practice Center (Shekelle et al., 2013). Patients with PUs often have longer inpatient stays, with some late-stage PUs leading to life-threatening infections (Shekelle et al., 2013). Bundles of interventions aimed at reducing the incident rate of PUs in acute and long-term care settings include organizational components, such as quality evaluation processes, educating staff, and altering policies and procedures; care-delivery prevention components, such as risk and skin assessments, moisture management, and hydration optimization; and care coordination components, such as meetings to facilitate communication (Shekelle et al., 2013). Although the specific interventions may differ between long-term and acute care settings, a combination of interventions from these different categories has been shown to reduce PUs in both care settings.

The national cost savings for PU prevention is estimated as the savings from avoided PU treatments minus the cost of PU prevention programs. The cost savings estimate presented here is primarily based on data from three sources: a systematic review of interventions designed to prevent in-facility PUs (Sullivan and Schoelles, 2013), an evaluation of a PU-reducing campaign at a 136-bed nursing facility (Rosen et al., 2006), and a pressure ulcer study at a 710-bed teaching hospital (Courtney et al., 2006). The cost of treatment for PUs is based on costs reported by Rosen et al. (2006) and Courtney et al. (2006). Because of limited intervention cost data on PU prevention programs, the intervention cost parameter is based on only on costs reported by Rosen et al. (2006). The intervention at this site included three main components: computer-based interactive video training to increase ability, a monetary incentivization program for completing the training and reaching predetermined targeted goals, and active management feedback.

Model

Net savings = benefits – costs

= savings from avoided PUs – PU intervention costs

= (number of in-facility PU incidents per year × relative reduction in PU incidents with intervention * mean cost of treatment of PU incident) –

(number of in-facility PU incidents per year × relative reduction in PU incidents with intervention × mean cost of PU intervention per incident averted)

Source Data

Parameter	Value	Year	References
Number of patients who develop PUs per year in acute and long-term care settings	1,000,000	2011 2013	Sharkey et al., 2011; Sullivan and Schoelles, 2013
Median percentage reduction in PUs due to interventions in acute care or long-term care settings	82% (range 67%–100%)	2013	Sullivan and Schoelles, 2013
Mean cost of treating PU incident in a hospital or nursing facility	$2,700 $3,037	2006 2001	Rosen et al., 2006; Courtney et al. 2006
Cost of PU intervention per 15 incidents avoided during a 12-week program in a nursing facility	$10,000	2006	Rosen et al., 2006

Model Input Assumptions

	Model Inputs		
Parameter	**Lower Bound**	**Base Case**	**Upper Bound**
Number of in-facility PU incidents per year		1,000,000	
Relative reduction in PU incidents with bundled interventions	67%	82%	100%
Cost of mean PU incident treatment	$3,332	$3,332	$4,619
Mean cost of PU intervention per incident averted	$823	$316	$190

NOTE: Dollar amounts are in 2012 U.S. dollars.

Number of in-facility PU incidents per year:

- The number of in-facility PU incidents per year is assumed to be 1,000,000. This is based on the reported number of patients who will develop PUs each year at acute and long-term care settings (Sharkey et al., 2011; Sullivan and Schoelles, 2013). This may be a conservative estimate of the total number of PU incidents per year, as patients can develop more than one PU.

Percentage reduction in PUs due to intervention (all from Sullivan and Schoelles, [2013]):

- Base case: It is assumed that there is an 82-percent reduction in PUs due to the intervention. This number is the median estimate identified in the systematic review.
- Lower bound: It is assumed that there is a 67-percent reduction in PUs due to the intervention. This number is the lower-bound estimate identified in the systematic review.
- Upper bound: It is assumed that there is a 100-percent reduction in PUs due to the intervention. This is the upper-bound estimate identified in the systematic review.

Mean cost of PU treatment:

- Base case and lower bound: The $3,332 cost of treatment is the adjusted value of the $2,700 (2006 U.S. dollars) average treatment cost for a stage II PU from Rosen et al. (2006). This treatment estimate is one of the most conservative identified in *Making Health Care Safer II: An Updated Critical Analysis of the Evidence for Patient Safety Practices* (Shekelle et al., 2013) and was used to calculate both the lower-bound and base case estimates.
- Upper bound: The average cost of PU treatment is assumed to be $4,619, which is adjusted from the treatment cost of $3,037 (2001 U.S. dollars) of a PU in a hospital setting from Courtney et al. (2006). A range of treatment estimates is identified in Shekelle et al. (2013); this treatment cost is one of the upper-bound estimates provided in the report.

Mean cost of PU intervention per incident averted per year:

- The PU prevention program costs are based on the intervention costs identified in the Rosen et al. study (2006) of a 12-week PU reduction campaign. It is assumed that the incentives distributed for completing the computer-based training and meeting the predetermined PU reduction goals account for the entire PU intervention cost. Prices for different bundles of interventions, as well as differences in price across geographical regions and care settings, would affect the cost of the intervention per incident. Because of limited data availability, the range of treatment costs is calculated by varying the frequency of incentive distribution. Parameters taken from Rosen et al. (2006) include
    - $10,000 (2006 U.S. dollars) distributed in incentives, and
    - 15 incidents averted during the 12-week study period, which is assumed to be a constant rate.
- Base case: The yearly intervention cost per incident averted is assumed to be $316. The base case intervention cost is the midpoint cost estimate between the lower-bound and upper-bound cases. This estimate might account for training of new employees and continued distribution of incentives for meeting predetermined goals.

- Lower bound: The yearly intervention cost is assumed to be $823 per incident averted. The lower-bound intervention cost is calculated based on a program that distributes the incentives every 12 weeks.
- Upper bound: The yearly intervention cost is assumed to be $190. The upper-bound intervention cost is calculated based on a program that distributes the incentives once a year.

Savings Estimates

	Annual Estimate ($ in millions)		
	Lower Bound	**Base Case**	**Upper Bound**
Benefits: Savings from prevention of PU incidents	$2,232	$2,732	$4,619
Costs: Costs of PU prevention interventions	$551	$260	$190
Net savings	**$1,681**	**$2,473**	**$4,429**

NOTE: Estimates are in millions of dollars and are adjusted to 2012 U.S. dollars.

Limitations

PUs in hospitals and long-term care facilities may have different causes and, thus, different interventions and costs. However, we chose to include the two care settings in our cost-savings analysis. Although the bundles of interventions may differ between these two care settings, the same framework guides PU interventions in both acute and long-term care facilities (though the cost of these interventions may differ between care settings). Because of a lack of data, we assume that the intervention costs of a PU prevention intervention across all care settings may be similar to those at a long-term care facility. This is a limitation of our cost estimate, as it is likely that the intervention costs would be higher for acute care settings.

Another limitation is the assumed relative reduction in PUs possible from intervention bundles. The 82-percent median reduction (range 67%–100%) is a pooled estimate from 11 studies that demonstrated statistically significant reductions (Sullivan and Schoelles, 2013). Although the range for this parameter is used in our estimates, studies that did not report reduction in PU rates and other unpublished interventions that may have observed lower rates (publication bias) are not incorporated in our estimates. There are many factors that influence the effectiveness of bundled interventions, but our estimated savings range assumes full implementation nationwide reaching the 82-percent (range 67%–100%) reduction level.

Use Ultrasound Guidance for Central Line Placement

The idea to promote ultrasound-guided catheter insertion is based on recommended practices from a patient safety evidence report prepared by the Southern California Evidence-Based Practice Center (Shekelle et al., 2013). The use of central venous catheters is necessary, but the placement process is risky. The traditional static "landmark" approach of using anatomic landmarks to determine the location of blood veins during catheter insertion is associated with such complications as arterial puncture, hematoma, and pneumothorax (Calvert et al., 2004). Studies have shown that using portable ultrasound devices that provide real-time imaging of central veins during the insertion process can decrease these risks significantly, lead to fewer failed catheter insertions, and also complete the insertion into the vein in less time (Calvert et al., 2004; Shekelle et al., 2013).

The cost savings estimate of using ultrasound-guided catheter insertion instead of landmark-guided catheter insertion is calculated by multiplying the number of catheter complications that can be avoided by using ultrasound-guided catheter insertion instead of landmark-guided catheter insertion per year by the dollars saved per complication averted, accounting for the cost of the intervention. The national cost estimate presented here is based on a cost-effectiveness evaluation of ultrasound-guided catheter insertion and landmark-guided catheter insertion in the United Kingdom (Calvert et al., 2004). The study considered equipment cost and maintenance, cost of training, and salaries of staff involved. Because of the lack of available data addressing costs of ultrasound-guided versus landmark-guided catheter insertion, all parameters are taken from this study. No upper or lower bounds are presented below; however, the effectiveness of ultrasound-guided insertion has been estimated to be much higher for different complications and insertion points (Hind et al., 2003; Shekelle et al., 2013).

Model

Net savings = total number of catheter insertions per year × percentage of complications per insertions avoidable using ultrasound-guided catheter insertion instead of landmark-guided catheter insertion × dollars saved per complication averted, accounting for cost of intervention

Source Data

Parameter	Value	Year	References
Total number of catheter insertions per year	5,000,000	2010	American College of Surgeons, 2010

Parameter	Value	Year	References
Percentage of complications per insertions avoidable using ultrasound-guided catheter insertion instead of landmark-guided catheter insertion	9%	2004	Calvert et al., 2004
Dollars saved per 90 complications averted in the United Kingdom, accounting for cost of intervention	$3,200	2002	Calvert et al., 2004; Shekelle et al., 2013
Health spending per capita in the United States	$7,538	2008	Squires, 2011
Health spending per capita in the United Kingdom	$3,129	2008	Squires, 2011

Model Input Assumptions

	Model inputs
Parameter	**Base case**
Total number of catheter insertions per year	5,000,000
Percentage of complications per insertions avoidable using ultrasound-guided catheter insertion instead of landmark-guided catheter insertion	9%
Dollars saved per complication averted, accounting for cost of intervention	$124

NOTE: Dollar amounts are in 2012 U.S. dollars.

Total number of catheter insertions per year:

- The number of catheter insertions per year is assumed to be 5 million. This number is based on the number of catheter insertions in 2010 according to the American College of Surgeons. It is assumed that this number is constant between years and that all of these catheter insertions are equally at risk for complications.

Percentage of complications per insertions avoidable using ultrasound-guided catheter insertion instead of landmark-guided catheter insertion:

- The percentage of complications that can be averted per insertion is assumed to be 9 percent. This estimate is based on the data available in Calvert et al. (2004) (90 complications avoided for every 1,000 patients). It is assumed that this risk is uniform across catheter insertion points and all complication types.

Dollars saved per complication averted, accounting for intervention costs:

- It is assumed that the amount saved per complication averted, accounting for intervention costs, is $124. This estimate is derived from parameters in Calvert et al. (2004). The amount saved per complication avoided was calculated by dividing $3,200 of savings by 90 complications and adjusting to 2012 U.S. dollars. To account for the difference in equipment and staff costs between the United Kingdom and the United States, this number was multiplied by the ratio of health spending per capita in the United States to health spending per capita in the United Kingdom in 2008. The parameters for this ratio are reported by a Commonwealth Fund study that compares U.S. health spending to 11 other countries (Squires, 2011). It is assumed that this conversion reflects the difference in cost for implementing an ultrasound-guided catheter insertion intervention between the United Kingdom and the United States.

Savings Estimates

	Annual Estimate ($ in millions)
	Base Case
Net savings	$56

NOTE: The estimate is in millions of dollars and is adjusted to 2012 U.S. dollars.

Limitations

Because of a lack of data availability, many of the parameter estimates in our cost savings model come from the Calvert et al. (2004) study of catheter insertion procedures in the United Kingdom. Our attempt to translate their estimates to the U.S. costs is very simplistic and may not reflect the differences in labor, machine, training, and hospital costs between the United States and United Kingdom for ultrasound catheter insertion. This is a limitation of our cost estimate, as we assume that our estimate reflects the true cost savings of using ultrasound-guided catheter insertion in place of landmark-guided catheter insertion in the United States. In addition, we did not explicitly account for any interventions outside of the Calvert et al. (2004) parameters, including the cost of encouraging ultrasound-guided catheter use across multiple care settings in the United States. This may lead to an overestimation of the cost savings associated with ultrasound-guided catheter use.

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