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Financial Risk of Building Design and Operation Interventions to Improve Patient Safety

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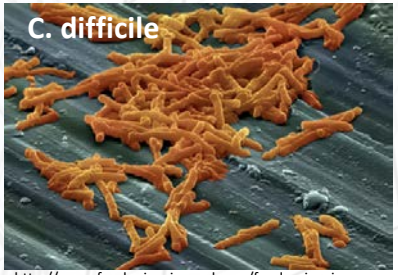
Health-Related and Financial Burdon of HAI

- Acinetobacter
- Burkholderia cepacia
- Clostridium difficile
- Clostridium sordellii
- Enterobacteriaceae (carbapenem-resistance)
- Gram-negative bacteria
- Hepatitis
- Human Immunodeficiency Virus (HIV)
- Influenza
- Klebsiella
- Methicillin-resistant Staphylococcus aureus (MRSA)
- Mycobacterium abscessus
- Norovirus
- Pseudomonas aeruginosa
- Staphylococcus aureus
- Tuberculosis (TB)
- Vancomycin-intermediate Staphylococcus aureus
- Vancomycin-resistant Staphylococcus aureus
- Vancomycin-resistant Enterococci (VRE)

https://misswalkerswiki.wikispaces.com/Pseudomonas+aeruginosa

http://www.cdc.gov/mrsa/community/photos/index.html

http://www.agefotostock.com/age/en/Stock-Images/Rights-Managed/BSI-1427705



http://www.foodpoisonjournal.com/food-poisoning-information/about-clostridium-difficile/#.VyEuzvkrKUk

In 2011, there were an estimated **722,000** HAIs in U.S. acute care hospitals (**75,000** patients died)

Health-Related and Financial Burdon of HAI

Cost per infection:

- Central Line-Associated Bloodstream Infection (CLABSI): **$45,814**
- Ventilator-Associated Pneumonia (VAP): **$40,144**
- Surgical Site Infection (SSI): **$20,785**
- Clostridium difficile infection: **$11,285**
- Catheter-Associated Urinary Tract Infections (CAUTI): **$896**

From: **Health Care–Associated Infections: A Meta-analysis of Costs and Financial Impact on the US Health Care System**
JAMA Intern Med. 2013;173(22):2039-2046. doi:10.1001/jamainternmed.2013.9763

Health-Related and Financial Burdon of HAI

- Total Attributable Financial Impacts of Health Care–Associated Infections in US Adult Inpatients at Acute Care Hospitals, 2009

CHIP spending (covers 8.9 million children) reached about **$13.6** billion in FY 2016.

Health Care-Associated Infection Type	Costs		
	Total	Lower Bound	Upper Bound
Surgical site infections	3 297 285 451	2 998 570 584	3 595 841 680
MRSA	990 539 052	93 785 080	1 935 883 296
Central line-associated blood-stream infections	1 851 384 347	1 249 464 195	2 636 608 279
MRSA	389 081 519	111 253 391	1 160 029 019
Catheter-associated urinary tract infections	27 884 193	18 765 813	37 002 574
Ventilator-associated pneumonia	3 094 270 016	2 796 898 212	3 408 445 101
Clostridium difficile infections	1 508 347 070	1 218 707 008	1 814 293 587
Total	**9 779 171 077**	**8 282 405 811**	**11 492 191 220**

Abbreviation: MRSA, methicillin-resistant *Staphylococcus aureus*.

[a] All cost estimates reported in 2012 $US rounded to the dollar.

From: **Health Care–Associated Infections: A Meta-analysis of Costs and Financial Impact on the US Health Care System**
JAMA Intern Med. 2013;173(22):2039-2046. doi:10.1001/jamainternmed.2013.9763

Multi-Bed versus Single-Bed Patient Rooms

http://https://www.redlandshospital.org/services/nicu/default.aspx

http://www.healthcaredesignmagazine.com/architecture/room-grow/

Single-Bed Versus Multi-Bed Patient Rooms

- Improve family experience
  - Family accommodations
  - Sense of control
  - Integration in the care process
  - Communication with caregivers

https://necsociety.org/2014/02/23/10-incredible-gifts-for-nicu-families/

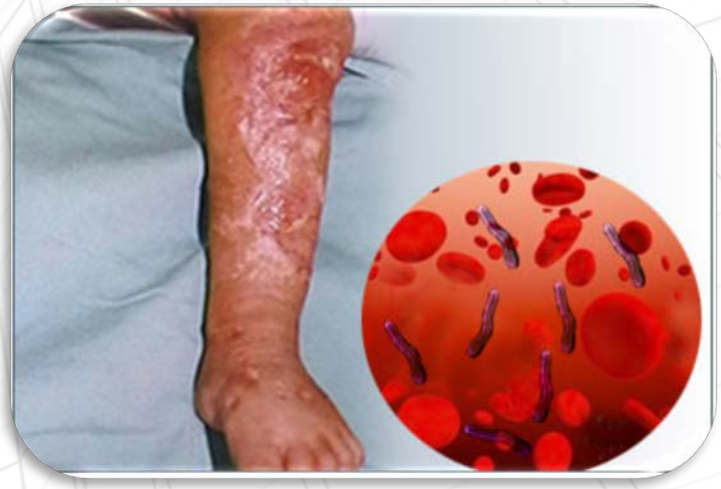
http://www.grhosp.on.ca/care/services-departments/childrens-program/nicu/your-babys-care

Single-Bed Versus Multi-Bed Patient Rooms

- Improve family experience
  - Family accommodations
  - Sense of control
  - Integration in the care process
  - Communication with caregivers

http://www.kangaroomothercare.com/productinfo.aspx

- Improve clinical/financial outcomes
  - Reduce length of stay
  - Control nosocomial infections
  - Lower cost of care



http://www.medindia.net/patients/patientinfo/septicemia.htm

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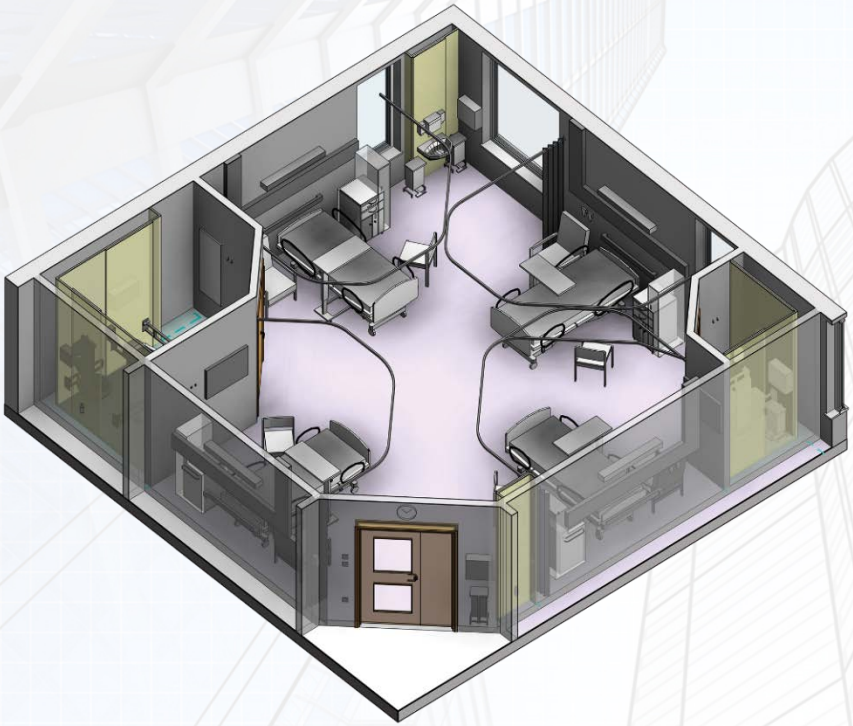
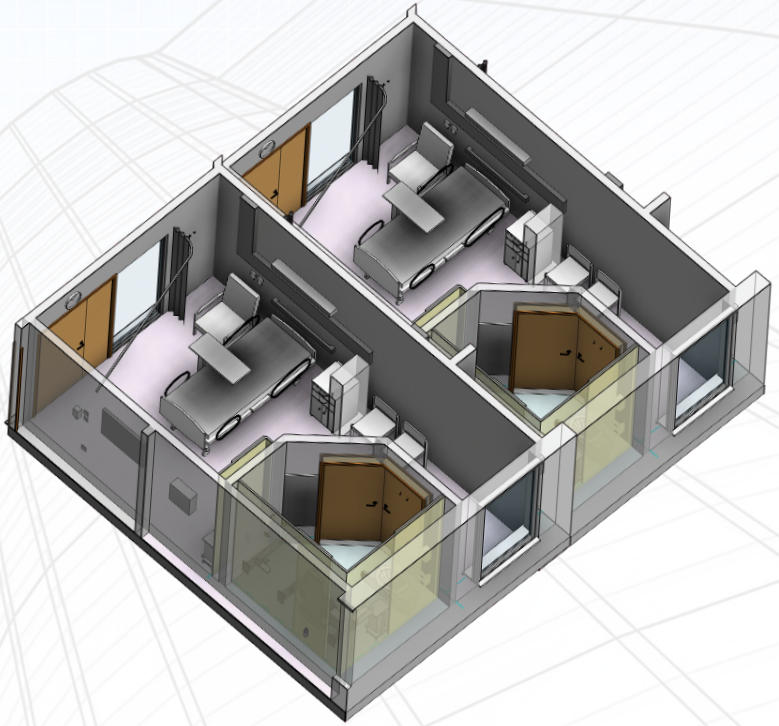
Single-Bed Versus Multi-Bed Patient Rooms





- NICU: minimum 165 sq.ft. clear in single-bed rooms versus 120 square feet clear in the multiple-bed rooms.

  White RD, Smith JA, Shepley MM. The Committee to Establish Recommended Standards for Newborn ICU Design. Recommended standards for newborn ICU design, eighth edition. J Perinatol 2013; 33: S2–16.

- ICU: 250 sq.ft. per bed and 20 sq.ft. for ancillary anterooms in single-bed rooms versus 225 sq.ft in multiple-bed rooms.

  Guidelines/Practice Parameters Committee of the American College of Critical Care Medicine SoCCM. Guidelines for intensive care unit design. Crit Care Med 1995; 23(3):582–8.

Single-Bed Versus Multi-Bed Patient Rooms

http://www.westeastdesign.com/higher-education-1/

32 beds X 120 sq.ft./bed = 3,840 sq.ft.

X 1.5 = 5,760 GSF

https://sparksandfavorpc.com/about-us/why-brookwood/

32 beds X 165 sq.ft./bed = 5,280 sq.ft.

X 1.5 = 7,920 GSF

Δ 2,160 GSF

Financial Evaluation

Our analysis represents a hypothetical 32-bed NICU:

Option I: 32 beds in bay rooms

Option II: 32 single-bed rooms

Financial Evaluation

We will perform an ***incremental analysis*** by looking at differences in costs and benefits between the two options.

This approach simplifies the analysis by excluding costs that are similar between the two scenarios:

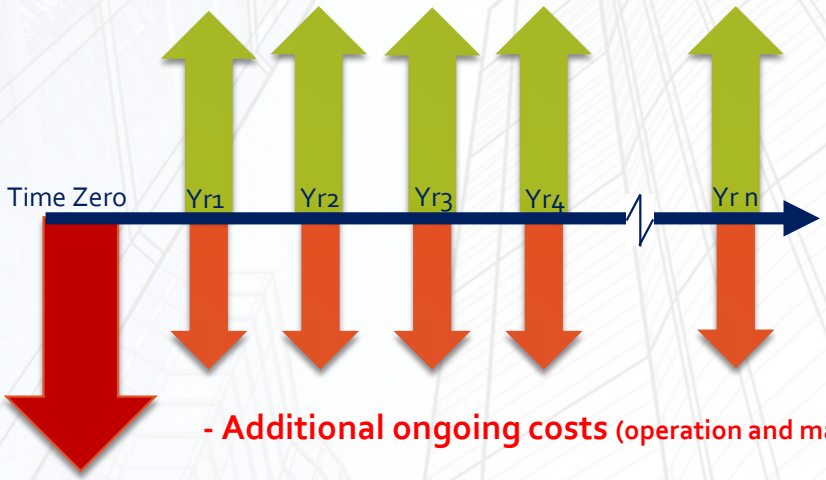
- Example: beds and medical devices

http://blueprints.ufhealth.org/2016/10/09/uf-health-shands-childrens-hospital-nicu-renovations-begin-jan-4/#prettyPhoto

http://www.ratcliffarch.com/projects/JMMCNICU

Financial Evaluation

- Ongoing savings



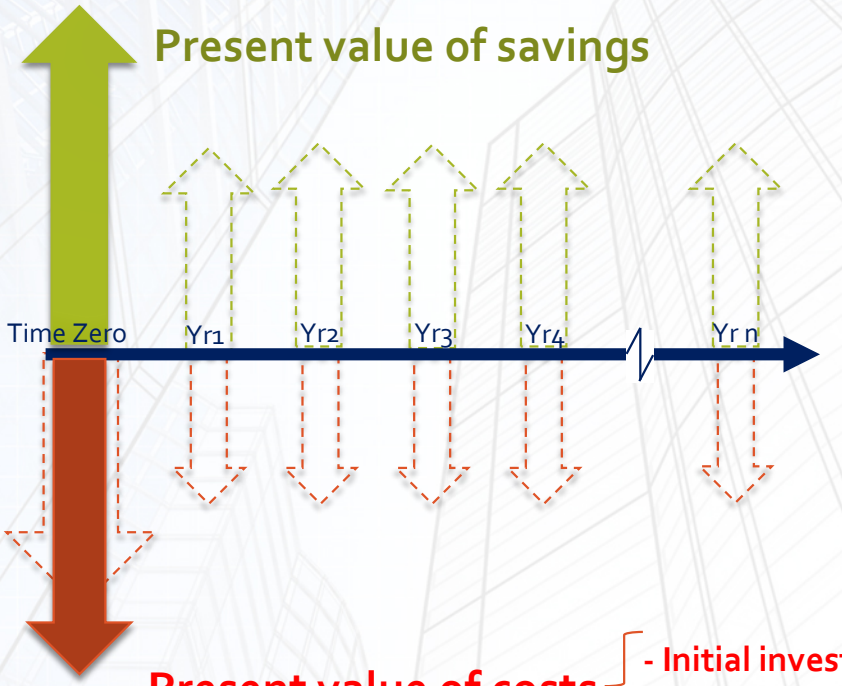
Positive cash flow (inflow)

Negative cash flow (outflow)

- Additional ongoing costs (operation and maintenance)

- Additional initial investment
(first costs)

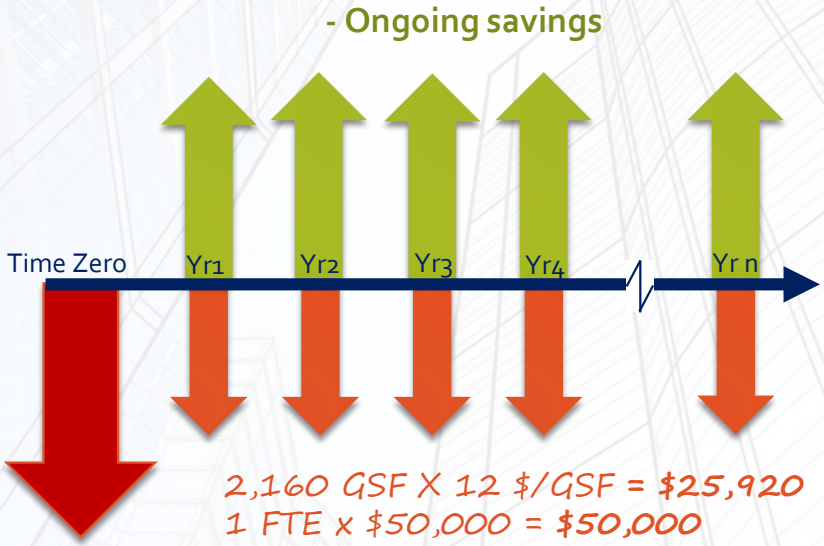
Financial Evaluation



I = 8% , n = 5

- Initial investment (first cost)
- Ongoing costs (operation and maintenance)

Financial Evaluation



2,160 GSF X 12 $/GSF = **$25,920** additional annual O&M costs
1 FTE x $50,000 = **$50,000** additional annual FTE costs

2,160 GSF
X 550 $/GSF = **$1,188,000**

total additional space
additional construction cost

Analysis Parameters

Analysis parameter	Baseline value
CONSTRUCTION AND OPERATION COSTS	
Additional construction costs of 32 SFRs versus OPBY beds	$1,188,000
Additional annual facility costs of SFRs versus OPBY unit	$25,920
Additional annual full time equivalent (FTE) costs in SFRs versus OPBY unit	$50,000
OUTCOME 1—NOSOCOMIAL INFECTIONS	
OUTCOME 2—LENGTH OF STAY	
OUTCOME 3—DIRECT COST OF CARE	

Analysis Parameters

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Additional annual full time equivalent (FTE) costs in SFRs versus OPBY unit	$50,000
OUTCOME 1—NOSOCOMIAL INFECTIONS	
Occupancy rate	80%
Survival rate of infants admitted to NICU	90%
Sepsis rate in OPBY unit (per 1,000 patient days)	2.08
MRSA rate in OPBY unit (per 1,000 patient days)	1.11
Relative ratio of sepsis in SFR versus OPBY unit	0.82
Relative ratio of MRSA in SFR versus OPBY unit	0.62
Infection mortality rate	10%
Extra costs of each incident of sepsis among infants who survived	$22,021
Extra costs of each incident of sepsis among infants who died	$52,150
Extra costs of each incident of MRSA among infants who survived	$57,685
Additional costs of MRSA for infants who died	50%
OUTCOME 2—LENGTH OF STAY	
Number of preterm patients per bed (per year)	7.105
Survival rate of infants below 37-week gestational age	87.5%
Length of stay in bay rooms (days)	4.9
Length of stay in SFR (days)	3.2
Daily cost of NICU care for each preterm patient	$1,566
OUTCOME 3—DIRECT COST OF CARE	
Percentage of multiple-birth	20%
Daily cost of NICU care per patient in OPBY unit	$1,044
Ratio of cost of bay rooms to cost of SFRs per patient	1.11

Analysis Parameters

Study	Observation Period	NICU Size	Total Patient Days Observed	Number of Infections
Pineda et al[b,20]	OPBY = 6 months	OPBY = 39 beds	OPBY = 4263[c]	OPBY = 17 (sepsis)
	SFR = 6 months	SFR = 36 beds	SFR = 4582[c]	SFR = 15 (sepsis)
Domanico et al[10]	OPBY = 87 days[d]	OPBY = 36 beds	OPBY = 1763[c]	OPBY = 14 (sepsis)
	SFR = 100 days[d]	SFR = 36 beds	SFR = 1586[c]	SFR = 6 (sepsis)
Julian et al[17]	OPBY = 29 months	OPBY = 37 beds	OPBY = 26 200	OPBY = 36 (sepsis), 29 (MRSA)[e]
	SFR = 29 months	SFR = 36 beds	SFR = 27 950	SFR = 36 (sepsis), 19 (MRSA)[e]
Pooled estimates for sepsis infection rate	-	-	OPBY = 32 226	OPBY = 67 (sepsis)
			SFR = 34 118	SFR = 57 (sepsis)

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; NICU, neonatal intensive care unit; OPBY, open-bay room; SFRs, single-family rooms.

[a]For each study, we calculated the rate of infections in each unit and then the relative incidence rate ratios in SFR versus OPBY units. Studies that reported early-onset sepsis or did not indicate the type of sepsis were excluded since early-onset sepsis occurs in the first 3 days of life and is typically caused by organisms transmitted from the mother to the infant before or at the time of birth.[30]

[b]Type of sepsis infection was clarified through personal communication with the authors on April 2, 2016.

[c]Calculated by multiplying the average length of stay by total number of eligible patients reported in each study.

[d]Davis, personal communication, February 12, 2014.

[e]Calculated by multiplying the incidence rate (%) by total number of eligible patients reported in the study.

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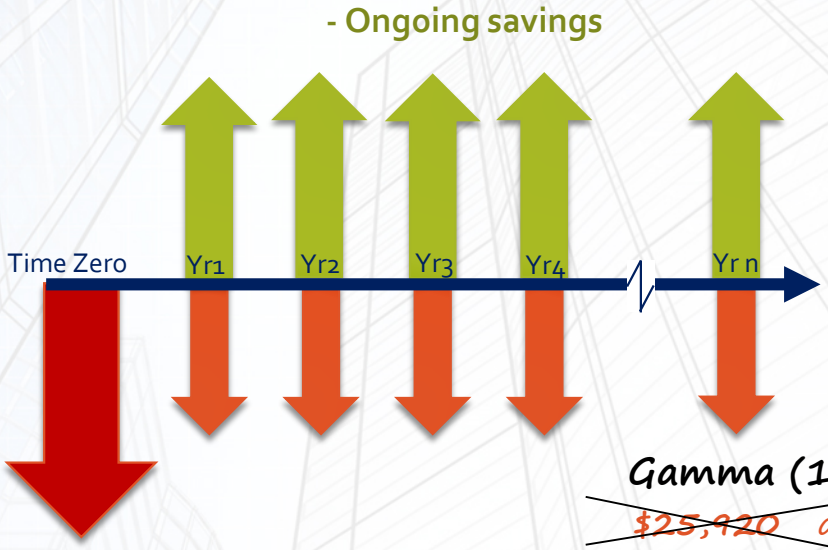
Financial Evaluation



~~$1,188,000~~ additional construction cost

gamma (100, 11,880)

Gamma (100, 259.2)

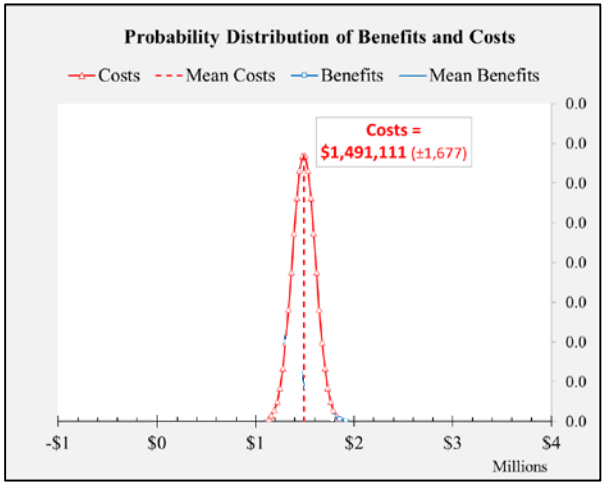
~~$25,920~~ additional annual O&M costs

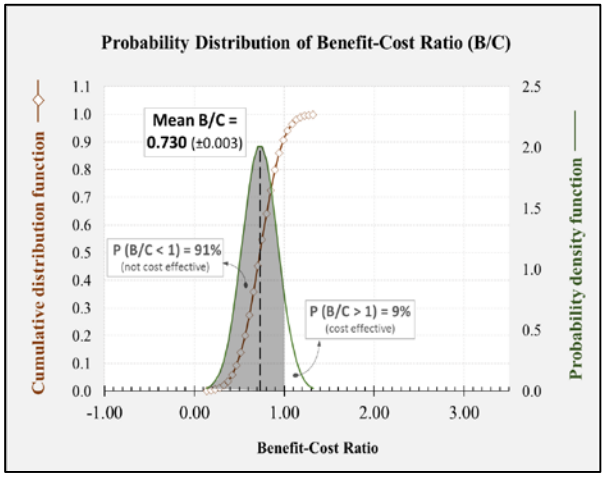
~~$50,000~~ additional annual FTE costs

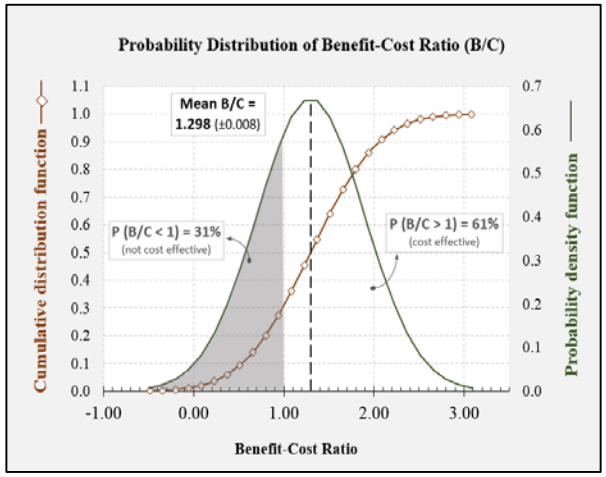
Gamma (100, 500)

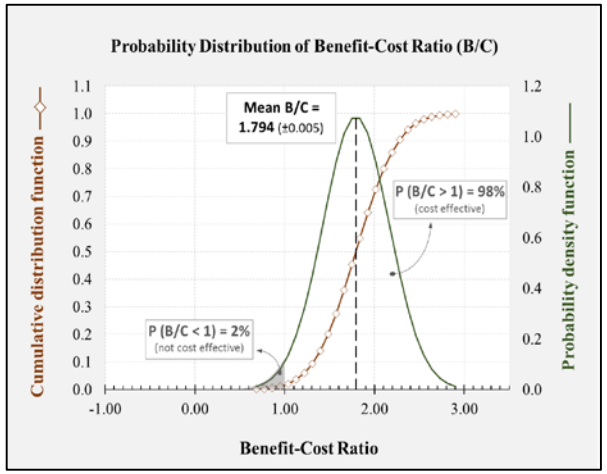
Results

Outcome 1 – Reductions in Infections









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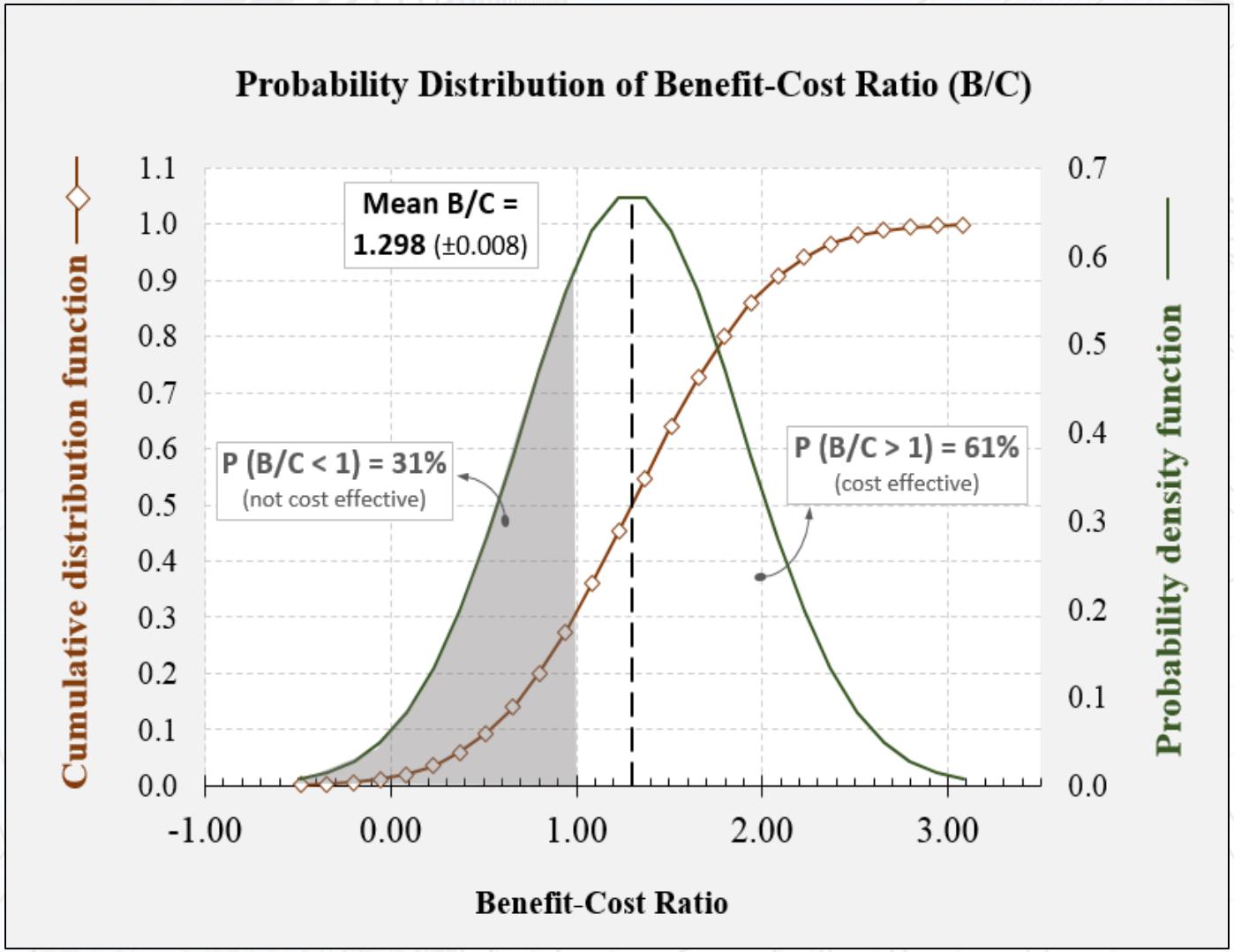
Risk Analysis



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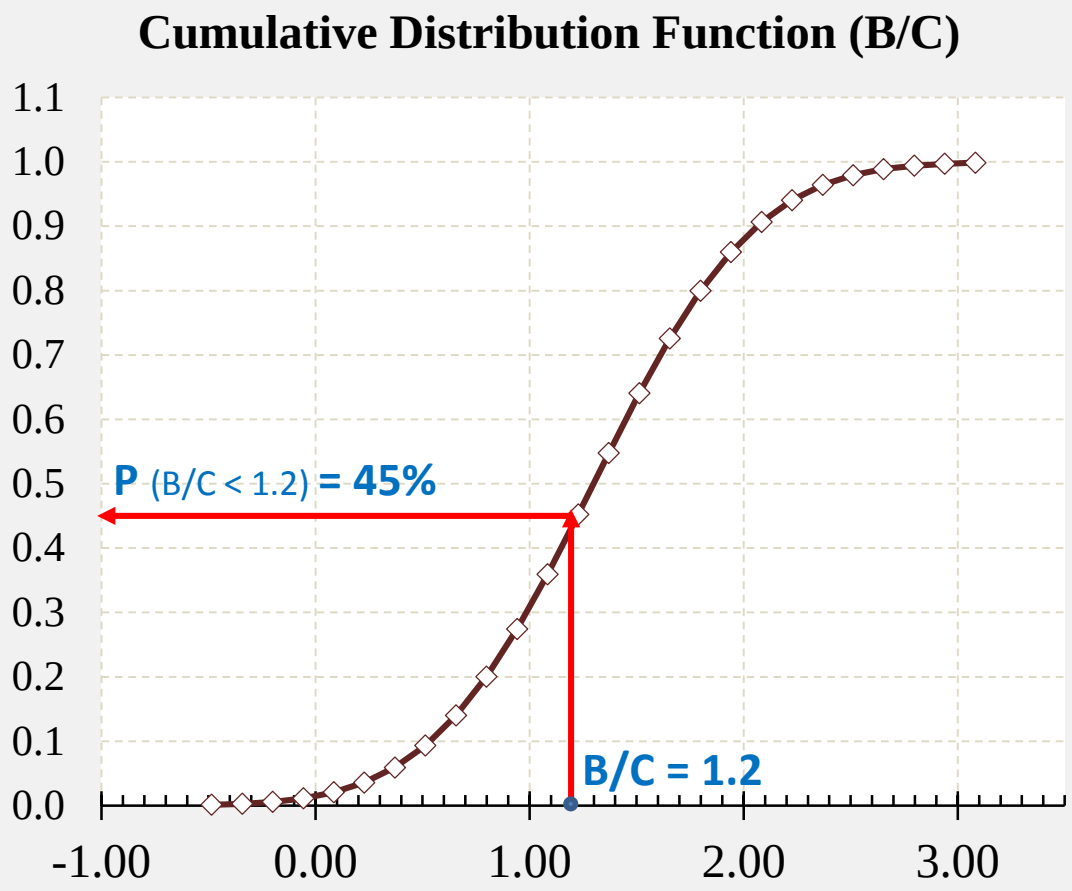

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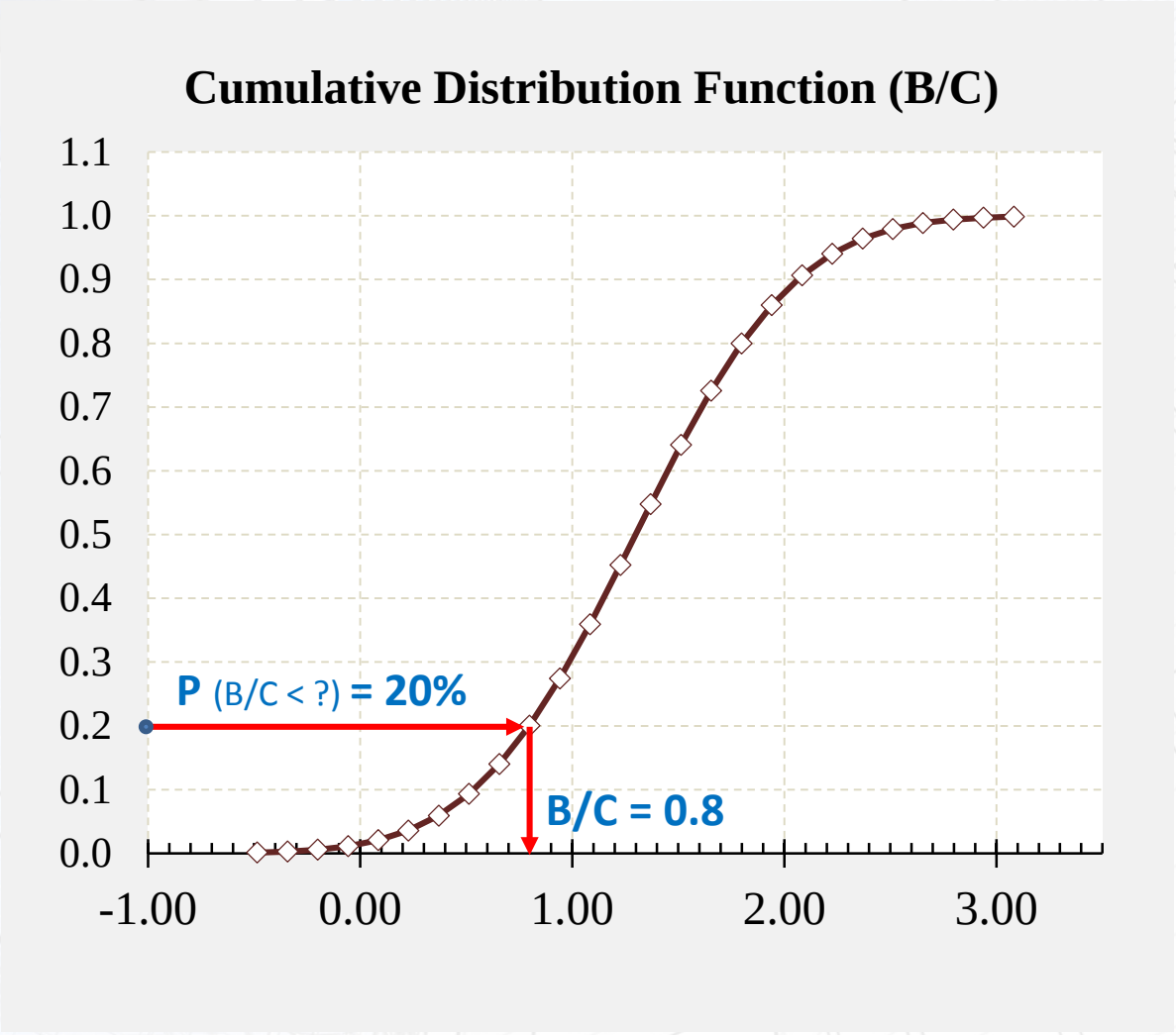

Sensitivity Analysis

Parameter	B/C When Changed by −10%	B/C When Changed by +10%	Value Required to Result in B/C = 1 Absolute Change (Relative Change) from Baseline
Outcome 1—Nosocomial infections (deterministic B/C using estimated means = 0.71[b])			
Additional construction costs	0.77	0.66	−US$433,447 (−37%)
Additional annual operating costs	0.71	0.70	−US$108,543 (−419%)
Additional annual FTE	0.72	0.70	−US$108,543 (−217%)
Occupancy rate	0.64	0.78	+3.84 (+41%)
Survival rate of infants admitted to NICU	0.64	0.78	+%37.02 (+41%)
Sepsis rate in OPBY unit (per 1000 patient days)	0.66	0.76	+1.30 (+62%)
MRSA rate in OPBY unit (per 1000 patient days)	0.68	0.73	+1.34 (+121%)
Relative ratio of sepsis in SFR versus OPBY unit	0.95	0.47	−0.10 (−12%)
Relative ratio of MRSA in SFR versus OPBY unit	0.75	0.67	−0.47 (−76%)
Infection mortality rate	0.70	0.71	+0.57 (+567%)
Extra costs of each incident of sepsis among infants who survived	0.69	0.73	+33 553 (+153%)
Extra costs of each incident of sepsis among infants who died	0.70	0.71	+301 973 (+580%)
Extra costs of each incident of MRSA among infants who survived	0.66	0.76	+35 587 (+62%)
Additional costs of MRSA for infants who died	0.70	0.72	+376 497 (+435%)
Outcome 2—Length of stay (deterministic B/C using estimated means = 1.29[b])			
Additional construction costs	1.40	1.19	+US$429 932 (+36%)
Additional annual operating costs	1.30	1.28	+US$107 609 (+415%)
Additional annual FTE	1.31	1.27	+US$107 609 (+216%)
Number of preterm patients per bed (per year)	1.16	1.42	−1.59 (−22%)
Survival rate of infants below 37-week gestational age	1.16	1.42	−19.61% (−22%)
Length of stay in OPBY rooms, days	0.87	1.70	−0.35 (−7%)
Length of stay in SFR, days	1.58	1.00	+0.35 (+10%)
Daily cost of NICU care per patient	1.16	1.42	−US$352 (−22%)
Outcome 3—Direct cost of care (deterministic B/C using estimated means = 1.71[b])			
Additional construction costs	1.86	1.59	+US$2 245 457 (+189%)
Additional annual operating costs	1.72	1.70	+US$264 707 (+1,021%)
Additional annual FTE	1.73	1.69	+US$264 707 (+530%)
Occupancy rate	1.54	1.88	−33.19 (−41%)
Survival rate of infants admitted to NICU	1.54	1.88	−35.39% (−41%)
Percentage of multiple birth	1.75	1.67	+33.19% (166%)
Cost of care per patient in bay rooms	1.54	1.88	−US$436 (−42%)
Relative ratio of cost per patient in OPBY unit versus SFRs unit	−0.08[c]	3.18	−0.05 (−4%)

Abbreviations: B/C, benefit–cost ratio, FTE, full-time equivalent; MRSA, methicillin-resistant *Staphylococcus aureus*; NICU, neonatal intensive care unit; OPBY, open-bay room; SFRs, single-family rooms.

[a]For this analysis, we used estimated means from 5000 Monte Carlo simulations, as shown in Table 1.

[b]Results are slightly different than those shown in Figure 1 due to rounding effects.

[c]10% reduction in cost ratio would result in cost ratio lower than 1 (0.995) and negative benefits (cost of care in bay rooms would be lower than cost of care in SFR).

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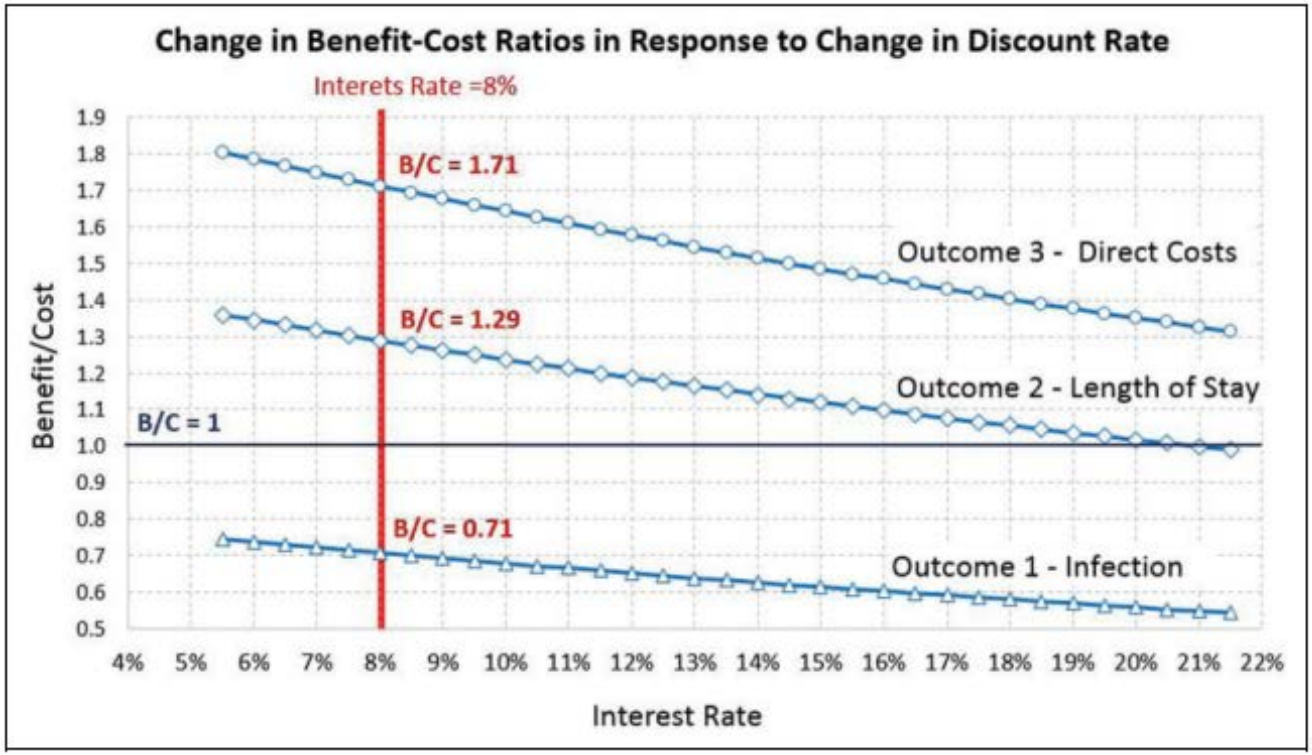
Sensitivity Analysis



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