**Supplementary Material:**

**Cost-Utility of Competing Strategies to Prevent Endoscopic Transmission of Carbapenem-Resistant Enterobacteriaceae**

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| **Supplementary Table 1. Detailed breakdown of base-case cost estimates.**  |
| **Variable**  | **Base-case estimate, $** |
| **Cost of admission for symptomatic CBD stones +/- cholangitis, ERCP without complication** |
| Emergency department physician fee | 176.27 |
| Medicare DRG 446 for hospital admission without complication | 6,124.81 |
| Internist admission consultation | 204.87 |
| Inpatient gastroenterologist consultation | 204.87 |
| Endoscopist’s procedure fee | 387.94 |
| Anesthesiologist’s fee | 202.47 |
| Follow-up visit by internist | 72.94/d x 3 days |
| Total cost | 7520.05 |
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| **Cost of admission for symptomatic CBD stones +/- cholangitis, ERCP with minor complication** |
| Emergency department physician fee | 176.27 |
| Medicare DRG 445 for hospital admission with minor complication | 8750.17 |
| Internist admission consultation | 204.87 |
| Inpatient gastroenterologist consultation | 204.87 |
| Endoscopist’s procedure fee | 387.94 |
| Anesthesiologist’s fee | 202.47 |
| Follow-up visit by internist | 72.94/d x 5 days |
|  Total cost | 10,291.29 |

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| **Supplementary Table 1. Detailed breakdown of base-case cost estimates (continued).**  |
| **Variable**  | **Base-case estimate, $**  |
| **Cost of admission for symptomatic CBD stones +/- cholangitis, ERCP with major complication** |
| Emergency department physician fee | 176.27 |
| Medicare DRG 444 for hospital admission with major complication | 12,880.69 |
| Internist admission consultation | 204.87 |
| Inpatient gastroenterologist consultation | 204.87 |
| Endoscopist’s procedure fee | 387.94 |
| Anesthesiologist’s fee | 202.47 |
| Follow-up visit by internist | 72.94/d x 7 days |
|  Total cost | 14,567.69 |
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| **Cost of admission for symptomatic CBD stones and cholangitis, PTC and LC/CBDE without complication** |
| Emergency department physician fee | 176.27 |
| Medicare DRG 413 for hospital admission without complication | 13,702.36 |
| Surgeon admission consultation | 204.87 |
| Interventional radiologist consultation | 204.87 |
| Interventional radiologist’s procedure fee | 487.69 |
| Surgeon’s procedure fee | 1149.16 |
| Anesthesiologist’s fee (for PTC and LC/CBDE) | 601.89 |
| Follow-up visit by surgeon  | 72.94/d x 5 days |
| Total cost | 16,891.81 |

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| **Supplementary Table 1. Detailed breakdown of base-case cost estimates (continued).**  |
| **Variable**  | **Base-case estimate, $** |
| **Cost of admission for symptomatic CBD stones and cholangitis, PTC and LC/CBDE with minor complication** |
| Emergency department physician fee | 176.27 |
| Medicare DRG 412 for hospital admission with minor complication | 19,524.56 |
| Surgeon admission consultation | 204.87 |
| Interventional radiologist consultation | 204.87 |
| Interventional radiologist’s procedure fee | 487.69 |
| Surgeon’s procedure fee | 1149.16 |
| Anesthesiologist’s fee (for PTC and LC/CBDE) | 601.89 |
| Follow-up visit by surgeon | 72.94/d x 7.5 days |
|  Total cost | 22,896.36 |
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| **Cost of admission for symptomatic CBD stones and cholangitis, PTC and LC/CBDE with major complication** |
| Emergency department physician fee | 176.27 |
| Medicare DRG 411 for hospital admission with major complication | 29,795.96 |
| Surgeon admission consultation | 204.87 |
| Interventional radiologist consultation | 204.87 |
| Interventional radiologist’s procedure fee | 487.69 |
| Surgeon’s procedure fee | 1149.16 |
| Anesthesiologist’s fee (for PTC and LC/CBDE) | 601.89 |
| Follow-up visit by surgeon | 72.94/d x 10 days |
|  Total cost | 33,350.11 |
| **Supplementary Table 1. Detailed breakdown of base-case cost estimates (continued).**  |  |
| **Variable**  | **Base-case estimate, $** |
| **Cost of admission for symptomatic CBD stones, LC/CBDE without complication** |
| Emergency department physician fee | 176.27 |
| Medicare DRG 413 for hospital admission without complication | 13,702.36 |
| Surgeon admission consultation | 204.87 |
| Surgeon’s procedure fee | 1149.16 |
| Anesthesiologist’s fee | 399.42 |
| Follow-up visit by surgeon | 72.94/d x 4 days |
|  Total cost | 15,923.84 |
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| **Cost of admission for symptomatic CBD stones, LC/CBDE with minor complication** |
| Emergency department physician fee | 176.27 |
| Medicare DRG 412 for hospital admission with minor complication | 19,524.56 |
| Surgeon admission consultation | 204.87 |
| Surgeon’s procedure fee | 1149.16 |
| Anesthesiologist’s fee  | 399.42 |
| Follow-up visit by surgeon | 72.94/d x 6.5 days |
|  Total cost | 21,928.39 |

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| **Supplementary Table 1. Detailed breakdown of base-case cost estimates (continued).**  |
| **Variable**  | **Base-case estimate, $** |
| **Cost of admission for symptomatic CBD stones, LC/CBDE with major complication** |
| Emergency department physician fee | 176.27 |
| Medicare DRG 411 for hospital admission with major complication | 29,795.96 |
| Surgeon admission consultation | 204.87 |
| Surgeon’s procedure fee | 1149.16 |
| Anesthesiologist’s fee | 399.42 |
| Follow-up visit by surgeon | 72.94/d x 9 days |
| Total cost | 32,382.14 |
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| **Cost of outpatient LC without complication** |
| Medicare Ambulatory Payment Classification 0131 for outpatient, elective LC | 3617.45 |
| Surgeon pre-procedure outpatient initial consultation | 204.87 |
| Surgeon’s procedure fee | 679.34 |
| Anesthesiologist’s fee  | 250.46 |
|  Total cost | 4752.12 |

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| **Supplementary Table 1. Detailed breakdown of base-case cost estimates (continued).**  |
| **Variable**  | **Base-case estimate, $** |
|  **Cost of admission for LC with minor complication** |
| Emergency department physician fee | 176.27 |
| Medicare DRG 418 for hospital admission with minor complication  | 12,737.27 |
|  Surgeon pre-procedure outpatient initial consultation | 204.87 |
|  Surgeon admission consultation | 204.87 |
| Surgeon’s procedure fee | 679.34 |
| Anesthesiologist’s fee  | 250.46 |
| Follow-up visit by surgeon | 72.94/d x 3 days |
|  Total cost | 14,471.90 |
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|  **Cost of admission for LC with major complication** |
| Emergency department physician fee | 176.27 |
| Medicare DRG 417 for hospital admission with major complication  | 17,714.00 |
| Surgeon pre-procedure outpatient initial consultation | 204.87 |
| Surgeon admission consultation | 204.87 |
|  Surgeon’s procedure fee | 679.34 |
| Anesthesiologist’s fee  | 250.46 |
| Follow-up visit by surgeon | 72.94/d x 5 days |
|  Total cost | 19,594.51 |

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| **Supplementary Table 1. Detailed breakdown of base-case cost estimates (continued).**  |  |
| **Variable**  | **Base-case estimate, $** |
|  **Cost of admission for CRE sepsis** |
|  Emergency department physician fee | 176.27 |
|  Medicare DRG (870/871) for hospital admission for severe CRE sepsis\* | 28,098.06 |
| Internist admission consultation | 204.87 |
| Infectious disease specialist consultation | 204.87 |
| Follow-up visit by internist | 72.94/d x 29 days |
| Follow-up visit by infectious disease specialist | 72.94/d x 29 days |
|  Total cost | 32,914.59 |
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| **FDA-recommended duodenoscope reprocessing** |
| High-level disinfection(1) | 67.62 |
| Smaller bristle cleaning brush† | 0.93 |
|  Total cost | 68.55 |

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| **Supplementary Table 1. Detailed breakdown of base-case cost estimates (continued).**  |  |
| **Variable**  | **Base-case estimate, $** |
| **Culture and hold strategy** |
| FDA-recommended duodenoscope reprocessing | 68.55 |
| 3% probability that culture is positive for CRE requiring repeat HLD reprocessing | 68.55 x .03 |
| Culture | 35.62 |
| 3% probability that culture is positive for CRE requiring another culture after repeat HLD  | 35.62 x .03 |
| 1.5% probability that duodenoscope has 2 successive positives cultures requiring EtO sterilization | 338.91 x .015 |
| 1% probability that duodenoscope damaged by EtO sterilization requiring replacement | 35,337.85 x .015 x .01 |
| Newly purchased duodenoscopes(2) / number of ERCPs per year | (35,337.85/scope x 8) / 1000 |
|  Total cost | 400.38 |
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| **EtO sterilization strategy** |
| FDA-recommended duodenoscope reprocessing | 68.55 |
| EtO sterilization‡ | 338.91 |
| 1% probability that duodenoscope damaged by EtO sterilization requiring replacement | 35,337.85 x .01 |
| Newly purchased duodenoscopes(2) / number of ERCPs per year | (35,337.85/scope x 8) / 1000 |
|  Total cost | 1043.54 |

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| **Supplementary Table 1. Detailed breakdown of base-case cost estimates (continued).**  |
| CBDE = common bile duct exploration; CRE = carbapenem-resistant Enterobacteriaceae; DRG = diagnosis-related group; ERCP = endoscopic retrograde cholangiopancreatography; EtO = ethylene oxide; HLD = high-level disinfection; FDA = Food and Drug Administration; LC = laparoscopic cholecystectomy; PTC = percutaneous transhepatic cholangiography.* Costs for hospital admissions were obtained from the Healthcare Cost and Utilization Project 2012 database by searching for pertinent Medicare DRGs.(3) Costs for physician services and procedures were obtained from the 2015 American Medical Association Current Procedural Terminology codebook and the 2015 Medicare Physician Fee Schedule.(4, 5) All estimates were updated to 2015 U.S. dollars by using the Consumer Price Index inflation calculator.(6)
* The following CPT codes were used in the model: emergency department physician fee (99285); physician initial admission/consultation fee (99223); physician follow-up visit fee (99232); endoscopist fee for ERCP (43262); surgeon fee for LC/CBDE (47564); surgeon fee for LC (47562); interventional radiologist fee for PTC (47510); culture (87071, 87077, 87186).
* Anesthesia fees were calculated using the following formula: (base units + time (in units)) x conversion factor. We used the 2015 national conversion factor of 22.4968. We used 7 base units for LC +/- CBDE (CPT 00790) and 5 base units for both ERCP and PTC (CPT 00740). For LC/CBDE, LC, ERCP, and PTC we assumed 10.8, 4.1, 4, and 4 time units, respectively.
* The length of stay (LOS) for an uncomplicated hospitalization for symptomatic CBD stones +/- cholangitis with ERCP was estimated to be 4 days.(7) For an uncomplicated hospitalization for symptomatic CBD stones with a LC/CBDE , we estimated the LOS to be 5 days.(8) For symptomatic CBD stone-related hospitalizations with a minor and major procedure-related complication, we assumed that the LOS was 1.5 and 2 times that of an uncomplicated hospitalization. Also, having concomitant cholangitis in the surgical arm added 1 extra day to the hospitalization because they underwent PTC tube placement. For those admitted to the hospital with a minor and major complication after outpatient LC, we assumed the LOS was 4 and 6 days, respectively. The LOS for hospitalizations related to CRE sepsis was estimated to be 30 days.(9-12)

\* Assumes 40% of those with CRE sepsis required intubation for ≥4 days (DRG 870); the remaining did not require intubation or were intubated for <4 days (DRG 871).†Cost has not been announced as of April 2015. Cost was estimated to be similar to the larger, currently available bristle cleaning brush (Olympus MAJ-1339).‡ Cost provided by Sterigenics International as of April 2015. Also includes courier costs to transport endoscopes from hospital to EtO sterilization facility. |

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| **SUPPLEMENT REFERENCES** |

1. Burdick JS, Hambrick D. Endoscope reprocessing and repair costs. Gastrointest Endosc Clin N Am 2004;14:717-24, ix-x.

2. Varadarajulu S, Banerjee S, Barth BA, et al. GI endoscopes. Gastrointest Endosc 2011;74:1-6 e6.

3. Agency for Healthcare Research and Quality. HCUPnet. 2015 [cited 2015 March 26]; Available from: <http://hcupnet.ahrq.gov/HCUPnet.jsp>

4. American Medical Association. CPT Code/Relative Value Search. 2015 [cited 2015 March 23]; Available from: <https://ocm.ama-assn.org/OCM/CPTRelativeValueSearch.do>

5. Centers for Medicare & Medicaid Services. Physician Fee Schedule Search. 2015 [cited 2015 March 26]; Available from: <http://www.cms.gov/apps/physician-fee-schedule/search/search-criteria.aspx>

6. Bureau of Labor Statistics. CPI Inflation Calculator. 2015 [cited 2015 April 6]; Available from: <http://www.bls.gov/data/inflation_calculator.htm>

7. James PD, Kaplan GG, Myers RP, et al. Decreasing mortality from acute biliary diseases that require endoscopic retrograde cholangiopancreatography: a nationwide cohort study. Clin Gastroenterol Hepatol 2014;12:1151-1159.e6.

8. Bansal VK, Misra MC, Rajan K, et al. Single-stage laparoscopic common bile duct exploration and cholecystectomy versus two-stage endoscopic stone extraction followed by laparoscopic cholecystectomy for patients with concomitant gallbladder stones and common bile duct stones: a randomized controlled trial. Surg Endosc 2014;28:875-85.

9. Chang HJ, Hsu PC, Yang CC, et al. Risk factors and outcomes of carbapenem-nonsusceptible Escherichia coli bacteremia: a matched case-control study. J Microbiol Immunol Infect 2011;44:125-30.

10. Epstein L, Hunter JC, Arwady MA, et al. New Delhi metallo-beta-lactamase-producing carbapenem-resistant Escherichia coli associated with exposure to duodenoscopes. JAMA 2014;312:1447-55.

11. Marchaim D, Chopra T, Perez F, et al. Outcomes and genetic relatedness of carbapenem-resistant enterobacteriaceae at Detroit medical center. Infect Control Hosp Epidemiol 2011;32:861-71.

12. Neuner EA, Yeh JY, Hall GS, et al. Treatment and outcomes in carbapenem-resistant Klebsiella pneumoniae bloodstream infections. Diagn Microbiol Infect Dis 2011;69:357-62.