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the implications for disposable colonoscopes

Larsen, Sara; Kalloo, Anthony; Hutfless, Susan

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The hidden cost of colonoscopy including cost of reprocessing and infection rate: the implications for disposable colonoscopes

Sara Larsen,[1] Anthony Kalloo,[2] Susan Hutfless[2,3,4]

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[1]School of Medicine and Health, Aalborg University, Aalborg, Denmark
[2]Department of Medicine, Division of Gastroenterology and Hepatology, Johns Hopkins University, Baltimore, Maryland, United States
[3]Gastrointestinal Epidemiology Research Center, Johns Hopkins University, Baltimore, Maryland, United States
[4]Department of Epidemiology, Johns Hopkins University Bloomberg School of Public Health, Baltimore, Maryland, United States

Correspondence to
Dr Susan Hutfless, Division of Gastroenterology, Johns Hopkins University, Baltimore, MD 21287, USA; shutfle1@jhmi.edu

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MESSAGE

Multiple studies have documented a high rate of contaminated colonoscopes after reprocessing. Contaminated reusable colonoscopes may increase the risk of device-related patient infections. As disposable colonoscopes enter the market, they may play a role in infection prevention and may be cost-effective at some facilities or in high-risk patients. Using a micro-costing approach, this study found that the cost per colonoscopy including purchase, maintenance and reprocessing ranges from US$188.64 at high volume centres (3000 annual procedures) to US$501.16 at low volume centres (1000 annual procedures). Accordingly, per-procedure capital costs range from US$87.48 to US$262.45; repair costs range from US$68.77 to US$206.32; cleaning supplies and labour costs US$32.39 and infections requiring hospitalisation cost US$20.12 to US$46.52. As disposable colonoscopes enter the market, low volume centres are most likely to achieve cost savings. Determining if post-procedural infection rates differ with reusable vs disposable colonoscopes is needed.

In more detail

Each year more than 15 million colonoscopy procedures are performed in the USA and the number is increasing.[1] Colonoscopy is generally thought to be safe; however, patients are sometimes hospitalised afterwards, due to infections that may have been transmitted via contaminated colonoscopes (MAUDE Adverse Event Report).[2 3] Colonoscopy-related infections and complications have been reported in multiple studies, although at lower rates compared with endoscopic retrograde cholangiopancreatography (ERCP).[1 4 5] Guideline revisions in response to endoscope-associated infections require healthcare institutions to invest more resources in the high-level disinfection process or conversion to sterilisation (Ofstead *et al*).[5 6] Despite colonoscopy being the highest volume GI procedure, the true cost and time associated with reusable colonoscopes are unknown. The purpose of this study was to explore real-world costs associated with reusable colonoscopes including capital costs and costs associated with reprocessing, personnel, maintenance, repair and postprocedural hospitalisation due to infection.

All cost data related to the usage of reusable colonoscopes were obtained at a high-volume outpatient endoscopy referral centre (Johns Hopkins Hospital, Baltimore, Maryland, USA) by tracking 25 colonoscope reprocessing procedures over a 3-day period. Cost data were collected in US dollars ($) using a micro-costing approach as this method allows for precise assessment of economic costs.[7] Cost per use of reusable colonoscopes were calculated fora range of annual procedures (1000, 2000 and 3000) performed with a fleet of 20 colonoscopes (US$35 000 per colonoscope) (Addendum) and extrapolated to different numbers of colonoscopes and procedure volumes (table 1). Automated endoscopic reprocessor (AER) cost calculations assumed two AERs to reprocess the colonoscopes available at the endoscopy unit (US$47 646.80 per AER (US$13863.01/year)) regardless of volume. Capital costs of the colonoscopes and their associated hardware and software were amortised over a 5-year period, and a discount rate of 3.5% was used to calculate the present value of capital expenditures. The AER and drying cabinets were amortised over an 8-year period. Average time spend on manual reprocessing was calculated for each reprocessing step. Costs related to initial and recurring training, education of personnel, time spent handling documentation for repair and retraining for compliance with latest reprocessing guidelines were not included. Average cost of repairs per AER is US$7831.25 per year. Each colonoscope was repaired 3.04 times per year on average at US$8609.94 per year (based on Johns Hopkins Service Contract Performance Reports, 2018).

Infection rates were 3.7 and 1.6 per 1000 procedures.[1 4] Costs of infection-related hospitalisation were collected from HCUPnet[8] which samples the 2016 National Inpatient Sample and the International Classification of Diseases 10th revision codes A04 and A09. Cost of infection was based on the assumption that all infected patients are treated at a hospital. Cost per treatment is US$12 574.28. Costs of postendoscopic infection hospitalisation per procedure were calculated by multiplying the infection rate and cost per hospitalisation (eg (1.16/1000)×US$12 574.28).

The cost associated with reusable colonoscopes ranges from US$188.64 to US$501.16 per procedure based on 20 colonoscopes (table 1 and online supplementary table 1 (addendum)). The per-procedure cost is highly dependent on the number of annual procedures and colonoscopes available at the facility (table 2). The time associated with

Table 1 Estimation of the per-procedure costs of reusable colonoscopes by varying number of annual procedures and number of colonoscopes

Summary of costs	1000 procedures (US$)	2000 procedures (US$)	3000 procedures (US$)	Costs that will remain with disposable endoscope
Capital costs				Yes. Purchase of disposable colonoscope per procedure only and monitor (lifespan approximately 5 years)
10 colonoscopes	184.93	92.47	61.64	
20 colonoscopes	**262.45**	**131.22**	**87.48**	
35 colonoscopes	378.73	189.36	126.24	
50 colonoscopes	495.00	247.50	165.00	
Repair costs				No
10 colonoscopes	120.22	60.11	40.07	
20 colonoscopes	**206.32**	**103.16**	**68.77**	
35 colonoscopes	335.47	167.74	111.82	
50 colonoscopes	464.62	232.31	154.87	
Precleaning, leak testing, manual cleaning, visual inspection, high-level disinfection, storage (including personal protective equipment)	**25.23**			No
Personnel time during pre-cleaning through high-level disinfection	**7.16**			No
Infection-related treatment* Per-procedure cost at different infection rates: 1.6/1000[1] and 0.37/100[4]	**20.12– 46.52**			Not for infections caused by endoscopic cross-contamination
Total				
10 colonoscopes	357.66–384.07	205.08–231.49	154.23–180.63	
20 colonoscopes	**521.28–547.69**	**286.89–313.30**	**208.76–235.17**	
35 colonoscopes	766.71–793.11	409.61–436.01	290.57–316.98	
50 colonoscopes	1012.12–1038.54	532.32–558.73	372.38–398.79	

Costs marked with bold font are the base-case numbers (ie, based on 20 colonoscopes). The message of this study is based on the base-case results. Other estimates are used to increase transparency and to make data comparable to other facilities.
*Assumption: all infected patients are treated at a hospital.

manual reprocessing was approximately 19 min per procedure. Divided into three major cost categories, the capital costs per procedure range from US$81.21 to US$243.63, costs of repair ranged from US$68.77 to US$206.59, and the costs of cleaning including labour ranged from US$39.91 to US$50.11. In addition, the costs of hospitalisation due to infection following colonoscopy ranged between US$20.12 and US$46.52 per procedure.

COMMENTS

It costs between US$188.64 and US$501.16 per colonoscopy including purchase, maintenance and reprocessing. Per-procedure costs increase an additional US$20.12 to US$46.52 if the postprocedural infections are included. Previous colonoscopy cost estimates range from US$114.07 to US$280.71 to reprocess the colonoscope; they did not consider the capital costs to purchase the equipment nor pay for postprocedural infections (Ofstead *et al*)[6] When we included only reprocessing and repair, our results are similar to the previous estimate at US$101.16 to US$238.71. The cost per colonoscopy is volume dependent based on the capital requirements of the colonoscope, its hardware and software and the AER, which was also found for duodenoscope and bronchoscope costs (Bang *et al*,[9] Ofstead *et al*[10]).

Our cost estimates are minimum estimates. The true cost may be even higher once overhead costs, additional reprocessing and equipment costs are considered (eg, additional reprocessing after 7 days storage, cost of disposing single-use accessories, conducting internal audits, water and electricity, etc). At facilities with many colonoscopes available, the cost of additional reprocessing after 7 days storage might be substantial due to a low volume per colonoscope. Previous reprocessing estimates range from US$20 to US$150 (average: US$69)[11] which is similar to our cost estimate of US$32.39. This study was not able to account for the cost of disposable colonoscopes because they have not entered the market yet. Disposal costs for colonoscopes will be a new cost, although it is anticipated to be similar to the cost of disposable bronchoscope disposal (US$0.06 per procedure).[12] Additionally, the environmental impact is somewhat equal for disposable bronchoscopes and reusable bronchoscopes but is highly dependent on the different reprocessing standards.[13] The per-procedure cost is dependent on differences in repair rate and costs, staffing costs and capital costs which may modify these estimates. Time spent on reprocessing in this study was relatively low (19 min compared with 76 min) (Ofstead *et al*[14]) and may reflect the focus on colonoscopes exclusively in this study.

The cost of reusable colonoscopes is highly dependent on the settings at each facility and especially the number of colonoscopes and annual volume of procedures. Disposable colonoscopes may decrease device-related infection transmission and may prove cost-effective for some facilities, particularly those with low-volume and high-infection risk patients. The true impact of disposable colonoscopes on infection and complication rates, cost-effectiveness and functionality for more difficult therapeutic procedures will remain unknown until they are widely available.

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Table 2 Cost of colonoscopy (in US$) including reprocessing, capital cost and repair cost by varying number of colonoscopes and annual number of procedures

Annual number of procedures															
		1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600
Number of colonoscopes available	5	255.73	218.51	191.92	171.98	156.47	144.06	133.91	125.45	118.29	112.15	106.84	102.18	98.08	94.43
	6	272.10	232.14	203.61	182.21	165.56	152.24	141.35	132.27	124.58	118.00	112.29	107.30	102.89	98.97
	7	288.46	245.78	215.29	192.43	174.65	160.42	148.78	139.08	130.88	123.84	117.74	112.41	107.70	103.52
	8	304.82	259.41	226.98	202.66	183.74	68.60	156.22	145.90	137.17	129.69	123.20	117.52	112.52	108.06
	9	321.18	273.05	238.67	212.88	192.83	176.78	163.66	152.72	143.46	135.53	128.65	122.64	117.33	112.61
	10	337.54	286.68	250.36	223.11	201.92	184.97	171.09	159.54	149.76	141.37	134.11	127.75	122.14	117.15
	11	353.90	300.32	262.04	233.34	211.01	193.15	178.53	166.35	156.05	147.22	139.56	132.86	126.95	121.70
	12	370.27	313.95	273.73	243.56	220.10	201.33	185.97	173.17	162.34	153.06	145.01	137.98	131.76	126.24
	13	386.63	327.59	285.42	253.79	229.19	209.51	193.41	179.99	168.63	158.90	150.47	143.09	136.58	130.79
	14	402.99	341.22	297.10	264.01	238.28	217.69	200.84	186.81	174.93	164.75	155.92	148.20	141.39	135.33
	15	419.35	354.86	308.79	274.24	247.37	225.87	208.28	193.62	181.22	170.59	161.38	153.31	146.20	139.88
	16	435.71	368.49	320.48	284.47	256.46	234.05	215.72	200.44	187.51	176.43	166.83	158.43	151.01	144.42
	17	452.07	382.13	332.16	294.69	265.55	242.23	223.16	207.26	193.81	182.28	172.28	163.54	155.83	148.97
	18	468.44	395.76	343.85	304.92	274.64	250.41	230.59	214.08	200.10	188.12	177.74	168.65	160.64	153.51
	19	484.80	409.40	355.54	315.14	283.73	258.59	238.03	220.89	206.39	193.96	183.19	173.77	165.45	158.06
	20	501.16	423.03	367.23	325.37	292.82	266.77	245.47	227.71	212.69	199.81	188.65	178.88	170.26	162.60
	21	517.52	436.67	378.91	335.60	301.91	274.96	252.90	234.53	218.98	205.65	194.10	183.99	175.07	167.15
	22	533.88	450.30	390.60	345.82	311.00	283.14	260.34	241.34	225.27	211.49	199.55	189.11	179.89	171.69
	23	550.25	463.94	402.29	356.05	320.09	291.32	267.78	248.16	231.56	217.34	205.01	194.22	184.70	176.24
	24	566.61	477.57	413.97	366.28	329.18	299.50	275.22	254.98	237.86	223.18	210.46	199.33	189.51	180.78
	25	582.97	491.21	425.66	376.50	338.27	307.68	282.65	261.80	244.15	229.02	215.92	204.45	194.32	185.33
	26	599.33	504.84	437.35	386.73	347.36	315.86	290.09	268.61	250.44	234.87	221.37	209.56	199.14	189.87
	27	615.69	518.48	449.03	396.95	356.45	324.04	297.53	275.43	256.74	240.71	226.82	214.67	203.95	194.42
	28	632.05	532.11	460.72	407.18	365.54	332.22	304.96	282.25	263.03	246.56	232.28	219.78	208.76	198.96
	29	648.42	545.75	472.41	417.41	374.63	340.40	312.40	289.07	269.32	252.40	237.73	224.90	213.57	203.51
	30	664.78	559.38	484.10	427.63	383.72	348.58	319.84	295.88	275.62	258.24	243.19	230.01	218.39	208.05
	31	681.14	573.01	495.78	437.86	392.81	356.76	327.28	302.70	281.91	264.09	248.64	235.12	223.20	212.60
	32	697.50	586.65	507.47	448.08	401.90	364.95	334.71	309.52	288.20	269.93	254.09	240.24	228.01	217.14
	33	713.86	600.28	519.16	458.31	410.99	373.13	342.15	316.34	294.49	275.77	259.55	245.35	232.82	221.69
	34	730.23	613.92	530.84	468.54	420.08	381.31	349.59	323.15	300.79	281.62	265.00	250.46	237.63	226.23
	35	746.59	627.55	542.53	478.76	429.17	389.49	357.02	329.97	307.08	287.46	270.45	255.58	242.45	230.78

The blue area indicates that the per-procedure cost has exceeded US$200. All estimates are minimum estimates and do *not* include cost of treatment due to postendoscopic infection (per-procedure cost of device-related infection ranges between US$20.12 and US$46.52). Costs related to repair and reprocessing will inevitably increase at high-volume facilities with high-volume colonoscopes.

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