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SPECIAL TOPIC

SSET Project: Cost-effectiveness Analysis of Surgical Specialty Emergency Trays in the Emergency Department

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Background: We hypothesize that reusable, on-site specialty instrument trays available to plastic surgery residents in the emergency department (ED) for bedside procedures are more cost-effective than disposable on-site and remote re-usable operating room (OR) instruments at our institution.

Methods: We completed a cost-effectiveness analysis comparing the use of disposable on-site kits and remote OR trays to a hypothetical, custom, reusable tray for ED procedures completed by PRS residents. Material costs of existing OR trays were used to estimate the purchasing and use-cost of a custom on-site tray for the same procedures. Cost of per procedure 'consult time' was estimated using procedure and resident salary.

Results: Sixteen bedside procedures were completed over a 4.5 month period. A mean of 2.14 disposable kits were used per-procedure. Mean consultation time was 1.66 hours. Procedures that used OR trays took 3 times as long as procedures that used on-site kits (4 vs. 1.1 hours). Necessary, additional instruments were unavailable for 75% of procedures. Mean cost of using disposable kits and OR trays was $115.03/procedure versus an estimated $26.67/procedure cost of using a custom tray, yielding $88.36/procedure cost-savings. Purchase of a single custom tray ($1,421.55) would be redeemed after 2.3 weeks at 1 procedure/day. Purchasing 4 trays has projected annual cost-savings of $26,565.20.

Conclusion: The purchase of specialized procedure trays will yield valuable time and cost-savings while providing quality patient care. Improving time efficiency will help achieve the Accreditation Council of Graduate Medical Education (ACGME) goals of maintaining resident well-being and developing quality improvement competency. *(Plast Reconstr Surg Glob Open 2018;6:e1591; doi: 10.1097/GOX.0000000000001591; Published online 11 January 2018.)*

INTRODUCTION

The delivery of efficient, timely, and cost-effective medical and surgical care has been discussed at length for the medical field as a whole, and within plastic surgery specifically.[1] The Accreditation Council of Graduate Medical Education (ACGME) has emphasized the importance of understanding the fundamentals of quality care delivery with the mandate of resident participation in quality improvement projects.[2] Thus, mastery of the principles of quality improvement has been incorporated into the competency-based Plastic Surgery Milestones Project by which residents are evaluated.[3]

The plastic and reconstructive surgery (PRS) service is routinely consulted by the emergency department (ED) to evaluate patients with complex soft-tissue or bony injuries. Disposable tools available on-site at our institution are often inappropriate for delicate bedside repairs. Obtaining sterile, reusable surgical instruments located in the operating room takes time, leads to increased patient wait times, and delays in patient disposition. Changes in this process will be particularly important as trauma volumes increase with the transition of our institution to a level 1 trauma center.

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In effort to streamline procedures completed in the ED and reduce associated costs, the goal of this study was to determine the cost difference between the actual cost of procedures completed by PRS residents using available materials [ie, disposable, on-site procedure kits (kits) and remote reusable instruments (OR tray)] and the theoretical cost of procedures completed using a custom on-site, quality plastic surgery procedure tray (PRS tray).

METHODS

Procedure Collection

PRS residents logged bedside procedures completed in the ED over a 4.5-month period (July 30, 2015–December 14, 2015). Documentation included number and type of procedures performed, type and source of instruments used, length of consultation, and additional instruments needed but not available.

Cost-effectiveness Analysis

A cost-effectiveness analysis of each bedside procedure was completed using costs related to the Kits (material and processing costs for both disposable Kits and reusable OR trays) and resident labor costs. Material costs for disposable kits were obtained from the institution's central supply inventory (Table 1). Processing costs for individual Kits were calculated using weight-based estimates of sharp instrument disposal by Stericycle (*Stericycle*, Lake Forest, Ill.) derived from institutional records. Institution-specific material processing costs for reusable OR Trays were calculated using methods described previously.[4,5] In brief, per-use processing costs for a single reusable OR tray were calculated based on instrument type, number of instruments, depreciation, utilities, and repair (Table 2). The estimated purchasing and processing cost of a hypothetical, custom on-site PRS tray for all logged procedures were also calculated in a similar fashion (Fig. 1).

Resident labor costs were calculated for the average time spent on each consultation using the average institutional resident salary per hour for an 80-hour workweek (Fiscal Year 2017). The hypothetical custom PRS tray would be available on-site. Thus, for the theoretical calculations using a custom PRS tray, average time spent on each consultation was modified to exclude procedures times that involved obtaining remote materials.

Cost differences between groups were compared. Specifically, cost savings for actual cost of completed procedures versus estimated cost for the same procedures using a PRS tray were calculated as above. Estimated per-procedure and annual cost savings were calculated.

RESULTS

Procedure Collection

Sixteen procedures of various types were completed over the study period (Fig. 2). Residents used a variety of instruments from both disposable Kits and reusable OR Tray (Fig. 3). The average number of disposable kits per procedure was 2.14, with 14 procedures using disposable kits and 29 disposable kits opened. Average consultation length was 1.66 hours. Average consultation length for procedures involving obtaining OR Trays were 4 hours versus 1.1 hours for those involving on-site, disposable kits (Fig. 4). Various additional tools were required but unavailable on-site for 75% of procedures ($n = 12$) (Fig. 5). Additional tools were not needed for incision and drainage procedures ($n = 3$) and trephination ($n = 1$).

Table 1. Material Costs for Disposable Kits

		Purchasing Cost	Processing Cost				Total Cost
Disposable Kit	Instrument	Purchasing Cost/Kit	Weight/Instrument (oz)	Processing Cost/Instrument ($0.01/oz)	Weight/Kit (oz)	Processing Cost/Kit	Total Cost/Kit (Purchasing + Processing)
Suture removal kit	Forcep		0.490	$0.005			
	Iris scissor	$1.15	0.610	$0.007	1.10	$0.01	$1.16
Laceration repair kit	Needle driver	$4.69	0.860	$0.009	2.70	$0.03	$4.72
	Iris scissor		0.630	$0.007			
	Tissue forcep		0.530	$0.006			
	Mosquito forcep		0.675	$0.007			
Incision and drainage kit	Scalpel	$209.76	0.300	$0.003	2.38	$0.03	$209.79
	Hemostat		0.930	$0.010			
	Scissors		0.930	$0.010			
	Forcep		0.220	$0.002			

Table 2. Material Costs for OR Trays

		Processing Cost			
Instrument Type	Number	Labor Closed = $0.05/use; Open = $0.09/use; Lumen = $0.18/use	Depreciation ($0.06/use)	Utilities and Repair ($0.23/use)	Total Processing Cost/Instrument
Closed	33	$1.65	$1.98	$7.59	$11.22
Open	42	$3.78	$2.52	$9.66	$15.96
Lumen	1	$0.18	$0.06	$0.23	$0.47
Total processing cost/tray		$5.61	$4.56	$17.48	$27.65

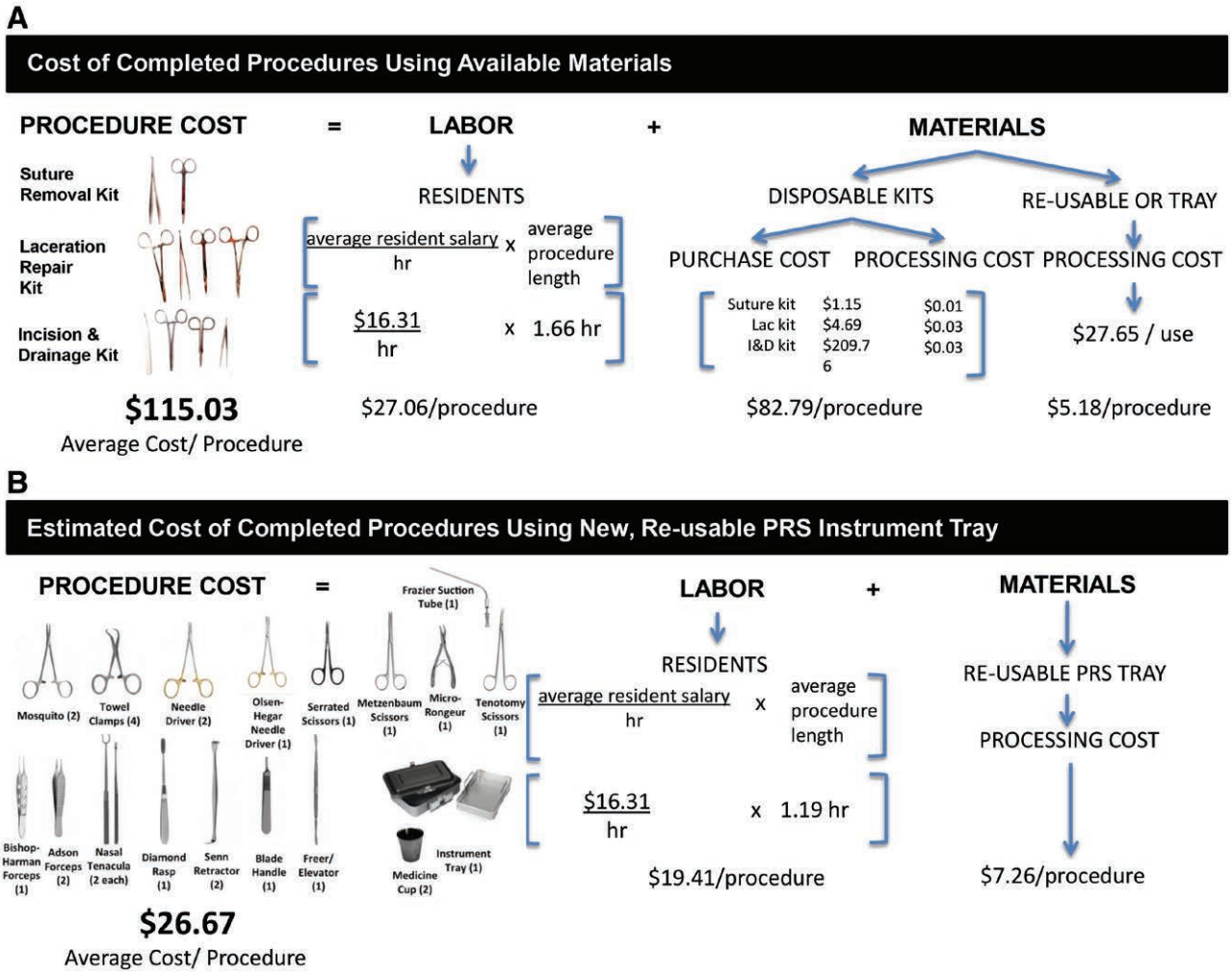

Fig. 1. Cost calculations of procedures completed in the ED by PRS residents. Per-procedure cost using existing on-site disposable and remote reusable OR instruments (A) and estimated cost using custom on-site PRS tray (B).

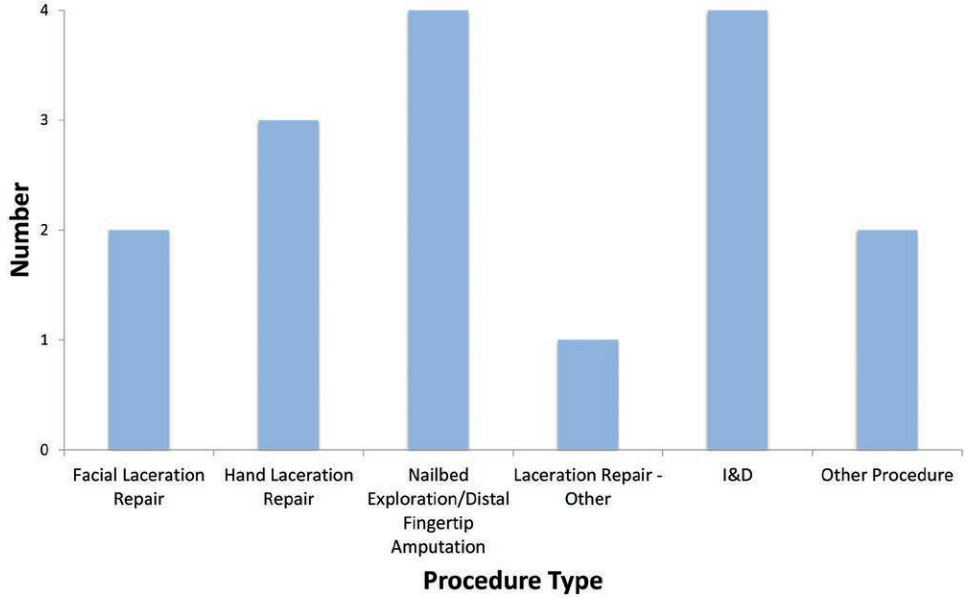

Fig. 2. Procedures completed in ED by PRS residents.

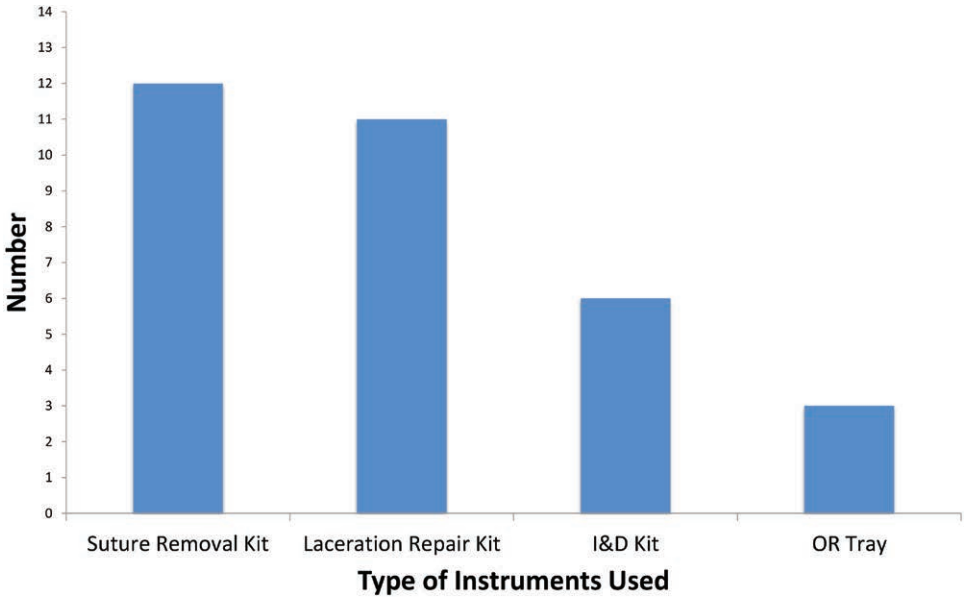

Fig. 3. Instruments used in the ED by PRS residents.

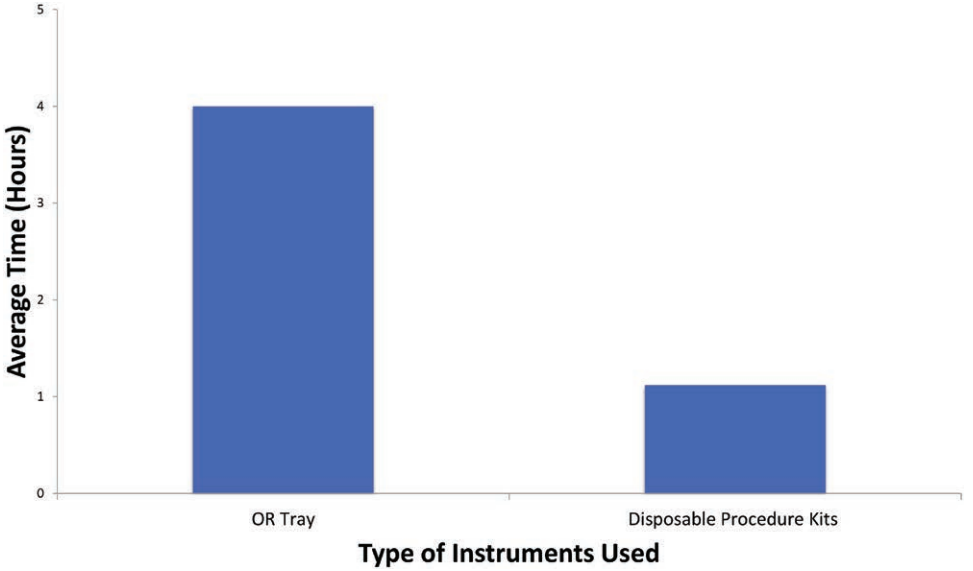

Fig. 4. Time per ED procedure by PRS residents.

Cost-effectiveness Analysis

Actual Per-Procedure Cost

Purchasing and processing of disposable kits were as follows: $1.16 for suture removal kit, $4.72 for laceration repair kit, and $209.79 for incision and drainage kit (Table 1). The processing cost for each kit was calculated using weight-based estimates. The total institutional waste processing cost per month was $80,451. Sharps accounted for 2.5% of the waste, with an estimated $2,011.28 per month. Average sharps waste was 11,314 pounds per month. Thus, the sharps waste processing per weight was $0.01 per ounce.

Per-use processing cost for OR Trays was $27.65 (Table 2). Average annual resident salary for FY 2017 was $62,643, which averaged to $16.31 per hour based on an 80-hour workweek. Resident labor costs were calculated to be $27.06 per procedure, with average consultation length of 1.66 hours. Thus, the average per-procedure cost of all logged cases was $105.03 (Fig. 1).

Estimated Per-Procedure Cost

The cost of purchasing a custom PRS tray that would be available on-site in the ED was calculated to be $1,421.55 through a single vendor (Fig. 1). The theoretical per-use processing cost of this tray was calculated to be $9.88 (Table 3). Resident labor costs were calculated to be $19.41 per procedure with average consultation time of 1.19 hours. Procedure lengths requiring the use of OR Trays were removed from average consultation time calculation as described in methods. Thus, the estimated average per-procedure cost of all logged cases was $26.67 (Fig. 1).

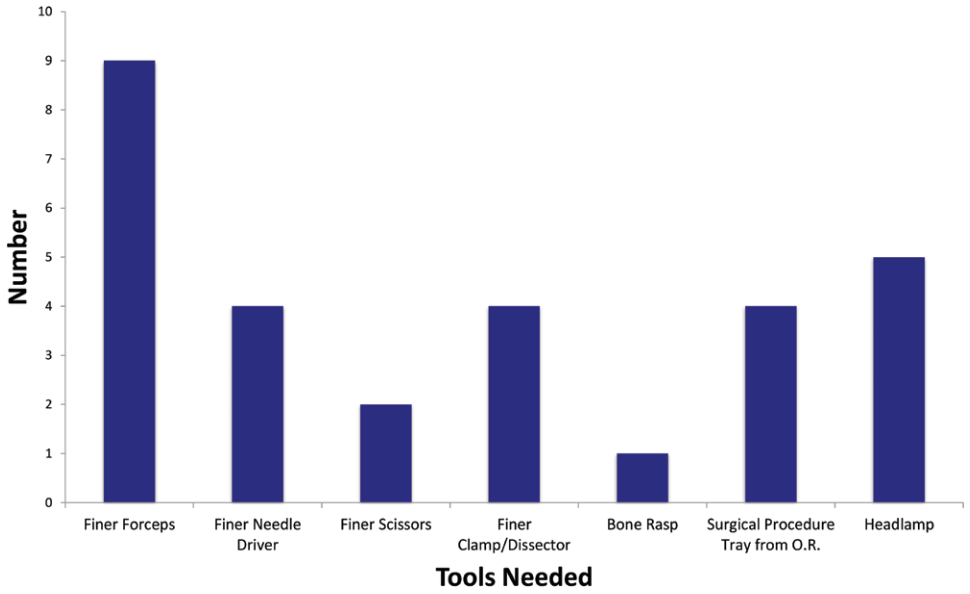

Fig. 5. Additional tools needed for ED procedures by PRS residents.

Table 3. Purchasing and Processing Cost for Custom PRS Tray

	Purchasing Cost			Processing Cost				
Instrument	Purchasing Cost/ Instrument	Number	Total Cost/ Instrument	Instrument Type	Labor Closed = $0.05; Open = $0.09	Depreciation	Utilities and Repair	Total Processing Cost/Instrument
Mosquito	$24.08	2	$48.16	Open	$0.09	$0.06	$0.23	$0.38
Towel forceps	$7.98	4	$31.92	Open	$0.36	$0.06	$0.23	$0.65
Webster needle driver	$70.42	2	$140.84	Open	$0.09	$0.06	$0.23	$0.38
Olsen-Hager needle driver	$97.71	1	$97.71	Closed	$0.05	$0.06	$0.23	$0.34
Iris scissors	$18.78	1	$18.78	Open	$0.09	$0.06	$0.23	$0.38
Metzenbaum scissors	$21.86	1	$21.86	Closed	$0.05	$0.06	$0.23	$0.34
Tenotomy scissors	$71.26	1	$71.26	Closed	$0.05	$0.06	$0.23	$0.34
Iris forceps	$71.91	2	$143.82	Closed	$0.05	$0.06	$0.23	$0.34
Adson forceps	$5.12	2	$10.24	Closed	$0.10	$0.06	$0.23	$0.39
2-mm nasal tenacula double hook	$34.70	2	$69.40	Closed	$0.10	$0.06	$0.23	$0.39
7-mm nasal tenacula double hook	$36.56	2	$73.12	Closed	$0.10	$0.06	$0.23	$0.39
Diamond rasp	$143.96	1	$143.96	Closed	$0.05	$0.06	$0.23	$0.34
Rongeur forceps	$363.72	1	$363.72	Open	$0.09	$0.06	$0.23	$0.38
Senn retractor	$9.85	2	$19.70	Closed	$0.10	$0.06	$0.23	$0.39
Knife handle	$4.66	1	$4.66	Closed	$0.05	$0.06	$0.23	$0.34
Freer Elevator	$23.24	1	$23.24	Closed	$0.05	$0.06	$0.23	$0.34
Frazier suction tubes	$33.72	1	$33.72	Closed	$0.18	$0.06	$0.23	$0.47
Medicine cup	$22.41	2	$44.82	Closed	$0.05	$0.06	$0.23	$0.34
Instrument basket	$60.62	1	$60.62	Closed	$0.05	$0.06	$0.23	$0.34
	Total purchasing cost/tray		$1,421.55	Total processing cost/tray	$1.75	$1.14	$4.37	$7.26

Estimated Cost Savings

The purchase and use of a single on-site PRS tray would yield per-procedure cost savings of $88.36 ($7.65 in resident salary costs and $80.71 in material costs). It is estimated that PRS residents perform 1 procedure per day in the ED on average versus the logged 16 procedures over 4.5 months. Thus, the logged procedures likely represent about 12% of actual procedures performed during the study time period. The cost of purchasing a single new PRS tray would be redeemed after about 16 uses of the tray or within about 2.3 weeks with 1 procedure per day use. The purchase of 4 PRS trays with an up-front purchasing cost of $5,686.20 and annual cost savings of $32,251.40 at 1 procedure per day would yield projected cost savings of $26,565.20 in the first year of PRS tray use.

DISCUSSION

With the rising costs of health care in the United States, the importance of implementing cost-saving measures is

paramount. Plastic surgeons have pioneered office-based procedures and demonstrated their cost-effectiveness in the private practice setting.[6] It would follow that optimizing PRS procedures in the acute setting in the ED would also yield cost benefits. This study supports the hypothesis that custom and reusable PRS procedure trays available in the ED for PRS use would yield time and cost efficiencies for our institution. Therefore, an initial up-front financial investment for the purchase of custom PRS trays would likely improve quality care delivery to patients.

This study is limited by small number of logged cases, which likely underrepresent actual number of procedures completed during the study time period. Based on informal resident survey after study completion, the actual number of bedside procedures completed by PRS residents is about 1 procedure per day. Thus, our study underestimates actual completed procedures by 88%. The number of procedures completed by plastic surgery residents in the ED will only increase in the coming months to years. Specifically, at our institution, nontrauma adult ED visits are estimated to increase by 6.51% per year, with 83,520 projected ED visits in the year 2021.[7] To address this increase in volume, our ED is expanding from a 36- to 41-bed unit. In addition to nontrauma visits, the institution expects 2,700 level 1 trauma visits per year once the trauma center opens in January 2018.[7] The expansion of emergency care services is projected to improve efficiency by decreasing average wait times from 7 to 4.5 hours. ED expansion is also projected to provide access to care for patients, 5,011 of whom in 2015 left the ED without being seen.[7]

In addition to increases in procedure volume, ED procedure variety and complexity will likely increase. Patients treated at our institution are already high acuity—45% of patients presenting to the ED were triaged to the 2 highest acuity categories.[7] Our patients are also complex—23% of patients receiving emergency care were admitted for inpatient care.[7] Trauma-related acuity and complexity will only increase the demands on emergency services. Life- or limb-threatening conditions will take priority over less acute trauma when it comes to operating room time and resource allocation. Thus, infrastructure for performing more complex procedures under monitored sedation or regional anesthesia may become necessary in the ED for a subset of trauma patients that do not fit the highest acuity (eg, "E.R. to O.R." criteria) or lowest acuity ("E.R. to Home") categories. Thus, with anticipated increases in volume, acuity, and complexity of patients at our institution, the availability of high-quality, on-site PRS specialty-specific procedure instruments is essential to efficiently delivering care to a subset of trauma patients in the ED.

Our study also aimed to factor in a cost associated with time spent per procedure, using time per consultation and resident salary to estimate associated costs. Notably, the procedures involving the use of remote OR trays took 3 hours longer on average than those that only required on-site disposable instruments. The reason for longer procedural times for those involving remote OR trays than on-site disposable instruments is unclear. This difference could be attributed in part to the cumbersome process of obtaining OR trays and/or increased complexity of these procedures that required the use of OR trays. It is also possible that the procedures took longer because they were more complex, thus necessitating the need for instruments for an OR tray. Other unknown factors that may contribute to length of procedure (evaluating multiple consults simultaneously, needing to wait for ER sedation, etc) may have impacted procedure length. In addition, resident salary was the best available factor to calculate time-associated costs in this study, although not completely accurate given that residents are not hourly workers.

Multiple factors may have contributed to higher procedural costs using disposable instruments. First, in several occasions, multiple different disposable kits were opened for a single procedure. The different disposable trays available in the ED contain different types and quality tools. Thus, although the disposable tools are unsuitable for more delicate repairs, tools from multiple trays may be needed. For example, the tissue forceps in the laceration repair kit have larger teeth than those in the suture removal kit, and the I&D kit contains smaller smooth forceps without teeth, the latter 2 of which may be more appropriate for delicate repairs. Neither the I&D kit nor the suture removal kit contains a needle driver, which is required for laceration repair.

Another factor contributing to higher procedural cost for procedures using disposable kits was the relative expense of the I&D kit. There were 4 I&D procedures that were completed and 6 I&D kits that were opened in this study. Two of the I&D kits were opened in a setting that did not involve and I&D (nail bed exploration/repair, finger laceration repair; and hand laceration repair); thus, the use of a scalpel alone versus an I&D kit in these cases may not have accomplished the goal of the procedure. For the 4 cases requiring an I&D, exchanging the cost of opening an I&D kit for a single disposable scalpel that costs $1.50 would result in the following change in cost difference. Average material cost per procedure would decrease to $35.68 from $82.79 and average total cost (material plus labor) per procedure would decrease to $62.75 from $115. If a disposable scalpel is used instead of opening the custom PRS tray for the 4 I&D procedures, then average per-procedure material cost would decrease to $5.82 from $7.26 (cost of processing a custom PRS tray for each procedure) and an average total cost (material plus labor) per procedure would decrease to $19.48 from $26.67. Thus, purchase and use of a custom PRS tray would still yield a per-procedure cost savings of $29.86 in materials ($35.68–$5.82) and $43.27 in total per-procedure cost ($62.75–$19.48). Although using a single scalpel in some situations may be more cost-effective than opening either a disposable I&D kit or a custom PRS tray, the overall benefit of the availability of a custom PRS tray outweighs its purchasing cost. At the rate of 1 procedure per day, the cost of the purchase of a single custom PRS tray at $1,421.55 would be redeemed at about 1 month (32 d) instead of 2.3 weeks as originally calculated.

Finally, the training level of the resident completing the procedure may impact the length of certain procedures. In revisiting the data, the following was noted:

logged procedures were completed by post-graduate year (PGY)-2 (n = 4), PGY-3 (n = 5), PGY-4 (n = 3), and PGY-5 (n =4) residents. Length of procedure did not correlate with PGY level (R^2 = 0.012) and in fact were most variable for the PGY-2 (range: 1–4 h) and PGY-5 levels (range: 0.3–5 h). Quality of the instruments used for repair may impact both the quality and the length of the repair. For example, use of relatively large disposable tissue forceps that require more force to adequately retract tissue may damage the soft tissue more so than using smaller reusable Bishop forceps with small teeth. Although choice of specific instruments may vary depending on training level, the availability of higher quality instruments for repair regardless of training level will improve the quality and efficiency of the repair across all training levels.

The cost analyses in this study focused on the impact of available quality procedural instruments in the ED for PRS use. Thus, the financial impact of other materials required for ED procedures (eg, medications, sutures, dressings) is not known. Additional studies and analyses are required to optimize cost and efficient use of these materials in the emergency care setting.

In addition to improving access to quality, efficient patient care, the institution of the above tools and processes will fulfill 2 goals of the ACGME. First, the ACGME has instituted a physician well-being initiative to help prevent physician burnout, including among trainees.[8] Instituting more efficient processes by specifically providing plastic surgery residents with appropriate tools to complete clinic work will help in achieving resident well-being. Second, both the ACGME and educators within plastic surgery have identified quality improvement as a core competency that resident physicians should begin to develop during training. The completion of this project and future extensions of it will help residents in our program achieve this goal.[2,3,9]

Moving forward, the next steps of this quality improvement project include the following: (1) the actual purchase of PRS trays; (2) the development of processes to store, transport, and process PRS trays as they are used on-site in the ED; (3) and the calculation of the actual cost savings accrued through the use of PRS trays in the ED. This project and those that follow will optimize the processes and procedures that deliver cost-effective and efficient care to patients cared for by the plastic surgery service in the acute care setting.

CONCLUSION

The purchase of specialized procedure trays will yield valuable time and cost savings while providing quality patient care. Improving time efficiency will help achieve the ACGME goals of maintaining resident well-being and developing quality improvement competency.

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REFERENCES

1. Hultman CS. Procedural portfolio planning in plastic surgery, part 2. *Ann Plast Surg.* 2016;76:S347–S351.
2. Schwentker AR. Quality improvement for plastic surgery residents: curriculum development. *Plast Reconstr Surg Glob Open* 2016;4:e1107.
3. McGrath MH. The plastic surgery milestone project. *J Grad Med Educ.* 2014;6:222–224.
4. Mhlaba JM, Stockert EW, Coronel M, et al. Surgical instrumentation: the true cost of instrument trays and a potential strategy for optimization. *J Hosp Adm.* 2015;4:82–89.
5. Stockert EW, Langerman A. Assessing the magnitude and costs of intraoperative inefficiencies attributable to surgical instrument trays. *J Am Coll Surg.* 2014;219:646–655.
6. LaBove G, Davison SP. Cost analysis of an office-based surgical suite. *Plast Reconstr Surg Glob Open* 2016;4:e803.
7. *State of Illinois Health Facilities and Services Review Board.* 2016:1–32. https://www.illinois.gov/sites/hfsrb/Projects/ProjectDocuments/2016/16-008/7.%2016-008%20University%20of%20Chicago%20Medical%20Center.pdf
8. Physician Well-Being Initiative, http://www.acgme.org/what-we-do/initiatives/physician-well-being. 2017. Accessed April 13, 2017.
9. Accreditation Council for Graduate Medical Education. June 2015:1–142, https://www.acgme.org/acgmeweb/Portals/0/ab_ACGMEPoliciesProcedures.pdf.