

ARTICLE

Assessing the Value of Pediatric Aerodigestive Care

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Leaders at six hospitals conducted a research study to assess and compare the health outcomes and costs of pediatric aerodigestive care. Four of the hospitals delivered care with an integrated practice unit (IPU) while two delivered care traditionally, with isolated specialists. The study used time-driven activity-based costing as a tool to measure and compare costs across the six sites. The results demonstrate that the four IPU sites improved clinical outcomes and had lower costs of care.

Value-based health care (VBHC) offers a unifying framework to help health care institutions deliver better outcomes to patients at lower societal cost.^{1,2} One of VBHC's principal tenets is the creation of an integrated practice unit (IPU). IPUs are composed of a team of medical and nonmedical specialists from different disciplines who deliver care for complex diseases that require multiple subspecialists, diagnostic tests, and procedures.^{2,3} Delivering care through an IPU has the potential to streamline diagnosis and treatment, facilitate the accurate measurement of health care outcomes and cost, and offer increased convenience for both patients and providers.

Patients and caregivers consistently report markedly improved patient experiences, even after a long day visiting with multiple providers. They also prefer the one-stop offering, as opposed to their past experiences with, or the prospect of, taking multiple days off from school and work to see individual providers, undergo sequential treatments when necessary, and attempt to develop their own diagnosis and treatment plan. The IPU approach promises to deliver the right care at the right time, at the right place, and by the right team in an efficient manner.

While delivering care through an IPU makes intuitive sense, skeptics and defenders of the status quo argue that an IPU is not cost-efficient for them or their institutions. For example, some clinicians might ask, "Why should I spend my time seeing eight patients in an IPU when I can see 20 people in the same amount of time in my regular clinic?" We used another VBHC

tool, time-driven activity-based costing (TDABC), to document and compare the actual clinical and administrative processes and their costs at four hospitals that have introduced an IPU for aerodigestive disorders, and at two hospitals that have yet to introduce an IPU for aerodigestive disorders.

An IPU for treating aerodigestive disorders was created in 1998 by Robin Cotton, MD (otolaryngologist–head and neck surgeon), and Robert Wood, MD, PhD (pulmonologist), at Cincinnati Children’s Hospital Medical Center in Ohio. They established the Aerodigestive and Sleep Center, now called the [Aerodigestive and Esophageal Center](#), to treat pediatric breathing disorders whose etiology intersected the disciplines of pediatric otolaryngology–head and neck surgery, pulmonology, and gastroenterology. This IPU addressed how subglottic stenosis — a form of airway scarring — could be caused by esophageal inflammation, food allergies, or eosinophilic esophagitis, and demonstrated that alleviating the gastroesophageal problem should be the first step in treating the airway problem.

In this paper, we study the role of an IPU in providing integrated care for children with breathing and swallowing difficulties. Difficulty in swallowing can be due to an array of disease processes whose resolution requires subspecialists from gastroenterology, pulmonology, otolaryngology–head and neck surgery, pediatric surgery, and speech-language pathology.^{4,5}

Without an IPU structure for treating breathing and swallowing disorders, patients must see specialist providers one at a time, in separate clinics, over several weeks or months. Patients and their families can feel stressed and inconvenienced as they bounce among fixed provider stations along their complicated treatment journey. Each provider assesses patients for disorders falling under their specialty’s umbrella. Once one provider confidently rules out diagnoses specific to their specialty, the patient is sent to another subspecialist.

In this model, the type of specialty provider encountered first often determines the course of treatment, especially when providers are reimbursed based on a fee-for-service model. This model can lead to worse health outcomes,⁶ such as inadequate weight gain, recurrent aspiration pneumonia, and interstitial lung disease. Also, delays in diagnosis can have deleterious effects on the health system, such as unanticipated physician office and emergency room visits, and hospital admissions. The fragmented care approach can leave patients and their families feeling frustrated, exhausted, and financially burdened due to the need for multiple appointments and delay of appropriate interventions (e.g., direct costs for appointments and travel, and indirect costs of missed days from work and unanticipated health care touches while awaiting intervention).

In contrast, an IPU structure allows initial evaluations and diagnostics to be performed during a single visit and for a team of specialists to agree upon and carry out a single treatment plan.⁷ Perhaps most important, the aerodigestive care IPU structure allows children to undergo flexible nasopharyngoscopy plus flexible bronchoscopy, rigid laryngoscopy and bronchoscopy, and esophagogastroduodenoscopy concurrently under one anesthetic rather than three anesthetics for three separate operating room procedures.

Previous studies investigating the cost savings and health benefits of aerodigestive care IPUs⁸⁻¹² used traditional cost accounting methods such as the ratio of cost to charges or relative-value-unit costing, which are inaccurate.² In this study, we used TDABC, an approach that measures costs based on the actual resources used to treat patients over their care cycle.^{13,14} This study builds upon Garcia et al. (2017)¹⁵ by also including outcomes and introduces a comparison between aerodigestive IPUs and treatment by collections of individual clinicians.

The primary aims of this study were to (1) assess the health outcomes and efficiency of pediatric aerodigestive care in an IPU, (2) validate the use of TDABC as a tool to measure IPU costs in a pediatric aerodigestive setting, and (3) compare the outcomes and efficiency of an aerodigestive IPU with the traditional approach of care delivered by isolated specialists. The secondary goals were to (1) illustrate how the process of implementing and analyzing TDABC data from some of the leading aerodigestive care IPUs across the country could be utilized collaboratively to identify areas for improvement of aerodigestive care, and (2) provide initial national data for introducing bundled payments for a full cycle of care for aerodigestive disorders by putting cost and quality into the value-based model.¹⁶

Testing a Better Approach

Leaders of aerodigestive IPU centers at four hospitals — Children’s Hospital Colorado in Aurora, Massachusetts Eye and Ear in Boston, Seattle Children’s Hospital, and the Children’s Hospital at Vanderbilt in Nashville, Tennessee — held a series of meetings to decide on and define the diagnostic condition to be studied to best accomplish the study goals (see Appendix).

“*Without an IPU structure for treating breathing and swallowing disorders, patients must see specialist providers one at a time, in separate clinics, over several weeks or months.*”

The leaders wanted to study a condition that represented a large percentage of the children seen within each aerodigestive IPU, had definable tiered outcomes, and had a clear 1-year full cycle of care with objective and patient- (caregiver-) reported outcome measures. They selected the treatment for pharyngeal phase dysphagia and aspiration in children ages 0 to 10 years. The cycle of care was defined as beginning with the initial clinic visit to the IPU and concluding 1 year following surgical repair of a laryngeal cleft for patients requiring it or 1 year following initial subspecialty diagnosis for those not requiring surgical repair.

Two additional children’s hospitals — Children’s Hospital of the King’s Daughters in Norfolk, Virginia, and the Hospital for Sick Children in Toronto — were chosen as controls. At the time of this study, these hospitals had not yet implemented an IPU structure to provide primary through quaternary care for children with pharyngeal phase dysphagia and aspiration.

Outcomes Measurement

The team used the Porter three-tier framework¹⁶ to measure treatment outcomes:

- Tier 1: Health status achieved immediately after medical or surgical therapy for pharyngeal phase dysphagia
- Tier 2: Process of recovery — patient and caregiver perspective
- Tier 3: Sustainability of health

The team selected two outcomes measurement instruments: (1) the Feeding/Swallowing Impact Survey (FS-IS), and (2) the videofluoroscopic swallow study (VFSS).

The Feeding/Swallowing Impact Survey

The FS-IS assesses the quality of life (QOL) of children with dysphagia and their caregivers.¹⁷ The instrument contains questions about QOL related to activities of daily living, feeding, and generalized worry, with five, six, and seven items asked in each category, respectively. Each question was scored using a five-point Likert scale, where lower scores indicated better QOL. The FS-IS has been validated to measure pre- and postoperative caregiver-related QOL changes after laryngeal cleft repair in children for aspiration.¹⁸

The FS-IS score was measured preoperatively, at 6 or 12 weeks post-procedure or diagnosis (the longer period for children with underlying neurologic issues and greater comorbidity), and at 1 year. The study received FS-IS survey scores from 164 caregivers of children with dysphagia, with a median patient age of 14 months.

Videofluoroscopic Swallow Studies

The four IPU and two control sites used the VFSS as the gold standard to evaluate children with dysphagia, although they supplemented VFSS with the Functional Endoscopic Evaluation of Swallowing. The imaging study evaluates the physiology of swallowing and is interpreted by a speech-language pathologist (SLP) or occupational therapist (OT).

Children undergoing aerodigestive care evaluation underwent VFSS initially and, at a minimum, 1 year post-procedure or diagnosis. The SLP/OT used the VFSS to document the improvement at the 1-year mark by a decrease of at least one-half consistency need for thickener (e.g., a child tolerated nectar-thick liquids preoperatively and tolerated thin/unmodified liquids postoperatively).

Cost Measurement

The team used TDABC^{9,16,17} to estimate treatment costs at the four IPUs and the two traditional clinics. TDABC requires estimation of two sets of parameters: (1) the time and the quantity of

resources used over each patient's treatment cycle and (2) the unit cost of all resource inputs (labor and nonlabor) as described in Figure 1.⁹

FIGURE 1

Step-by-Step TDABC Analysis

1. Develop process maps with the following principles:
 - a. Each step reflects an activity in patient care delivery
 - b. Identify the resources involved for the patient at each step
 - c. Identify any supplies used for the patient at each step
2. Obtain time estimates for each process step through interviews and observations
3. Calculate the capacity cost rate (CCR) for each resource:

$$CCR \text{ of Resource } A = \frac{(\text{Expenses attributable to Resource } A)}{(\text{Practical capacity of Resource } A)}$$

4. Calculate the total direct costs (i.e., personnel, equipment, space, and supplies) of all the resources used over the cycle of care

Source: Kaplan RS, and Porter, ME. How to Solve the Cost Crisis in Health Care. Harvard Business Review; September 2011:3–14. <https://hbr.org/2011/09/how-to-solve-the-cost-crisis-in-health-care>.

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A process map is a visual representation of all the activities performed during the patient's care cycle along with the average time, the personnel type, and space and equipment required to complete each activity. Process maps (as referenced in steps 1 and 2 in Figure 1) are developed by observing patients through their care cycle and conducting interviews and surveys with the clinical and administrative personnel who treat them.

The capacity cost rate (CCR), step 3 of TDABC, calculates the cost per minute for all personnel, equipment, and space used during the patient's care cycle. Personnel costs — salary and fringe benefits — were obtained from financial managers at each site or estimated from Salary.com for each regional area when site data were not available. The practical capacity of each personnel type was calculated as the number of clinical minutes available for professional work per year, excluding time for breaks, meetings, training, vacation, and holidays. CCRs for equipment were derived from the cost of purchase, estimated useful life, cleaning and maintenance costs, and depreciation rates divided by the quantity of annual available minutes for each equipment type. CCRs for all resources were measured as a dollar-per-minute rate. CCRs for hospital and clinic spaces were calculated by dividing annual rent and maintenance costs by the space used during each step in the aerodigestive care cycle.

“ *The aerodigestive care IPU structure allows children to undergo flexible nasopharyngoscopy plus flexible bronchoscopy, rigid laryngoscopy and bronchoscopy, and esophagogastroduodenoscopy concurrently under one anesthetic rather than three anesthetics for three separate operating room procedures.*”

The total direct costs to treat patients with aerodigestive disorders are calculated in step 4 (Figure 1) by multiplying the CCR for each resource (personnel, equipment, and space) by the average minutes that the resource was used for each activity step, and adding the cost of any supplies used at that step.

Project teams at each site developed the process maps to capture every interaction between the patient and the clinic during the complete care cycle. Developing these process maps and collecting time data were joint efforts first spearheaded by a meeting of the project team and clinicians, and then carried out primarily by the project team, with a series of summary and revision meetings prior to finalizing the maps and timing. (Please see the Challenges section for further discussion). Once they understood the rationale for the process maps and timing, the clinicians involved did not report undue time burden to accomplish them, nor did they feel the study slowed or affected their clinical care. (Although they did note how critical an administrative program team was to carry out this form of study.)

The care cycle started with a patient referral to the aerodigestive care IPU and continued through check-in at the hospital, the full suite of care provided by each member of the team, and all procedures and tests administered. It concluded with the patient's discharge from the program or interval evaluation at 1 year. The project teams estimated process times through discussions with physicians, nurses, and administrative assistants. The process steps and times were validated by directly observing patients progressing through all steps of the care cycle. In addition, project teams estimated the space used for patient-clinician interactions and identified any equipment usage at each step. At the two control sites, we also developed process maps for the traditional treatment of aerodigestive disorders, which require separate visits by patients and their caregivers for otolaryngology, gastroenterology, pulmonary, and speech pathology services.

All four centers obtained institutional review board approval or exception. Harvard Business School and Massachusetts Eye and Ear coordinated and summarized the data from all six sites.

Retrospective chart review was performed to identify the date of initial visit for each patient enrolled in the study, date of combination endoscopy, and date of laryngeal cleft repair, as applicable. The number of visits to each aerodigestive care IPU was quantified during the care cycle of each patient by documenting the number of notes entered in patient charts.

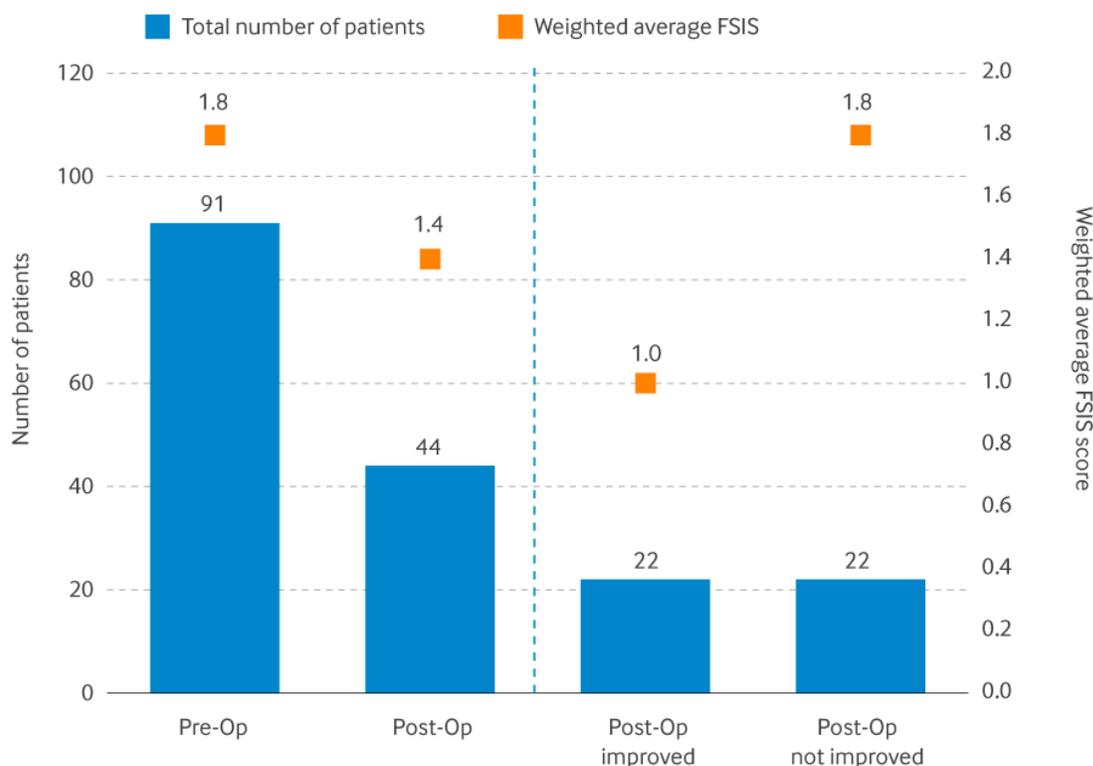
Health Outcomes in Aerodigestive Care

The health outcome measures of VFSS and FS-IS identified overall improvement in health status for patients receiving aerodigestive care from the IPUs, reflecting an overall decrease in average FS-IS from 1.8 pre-op to 1.4 post-op (range: 0.21–4.4 pre-op, 0.11–3.9 post-op) (Figure 1). Post-op patients were stratified according to binary improved or not-improved categories, with improvement based on oral feeding advancement by at least one-half of a consistency or greater based on VFSS results. Patients' mean post-op FS-IS scores were significantly lower in the improved group at 1.0 (range: 0.11–2.56) and remained unchanged in the not-improved group at 1.8 (range: 0.11–3.9) (Figure 2). Statistical analysis was performed using Microsoft Excel utilizing a two-tailed student t-test with unequal variance to compare changes in pre- versus postoperative FS-IS scores in the improved and not-improved groups, with $p < 0.05$.

FIGURE 2

Aggregated Outcome Measures at the Four IPU Sites

The aggregated IPU outcomes measures are the data from the IPUs across treatment of the specified condition. Total preop patients identified were 91 with an average FS-IS of 1.8. Total postop patients were 44 with an average FS-IS of 1.4, noting improvement of health with aerodigestive IPU care. After further stratifying patients based on the gold-standard health outcome, postop patients with VFSS improvement showed an FS-IS of 1.0, and without VFSS improvement an FSIS of 1.8. The preop and postop patients are not paired results. A statistical analysis was performed with Microsoft Excel utilizing a two-tailed student t-test with unequal variance of two samples for comparisons with a cutoff for significance of $p < 0.05$.



Source: The authors

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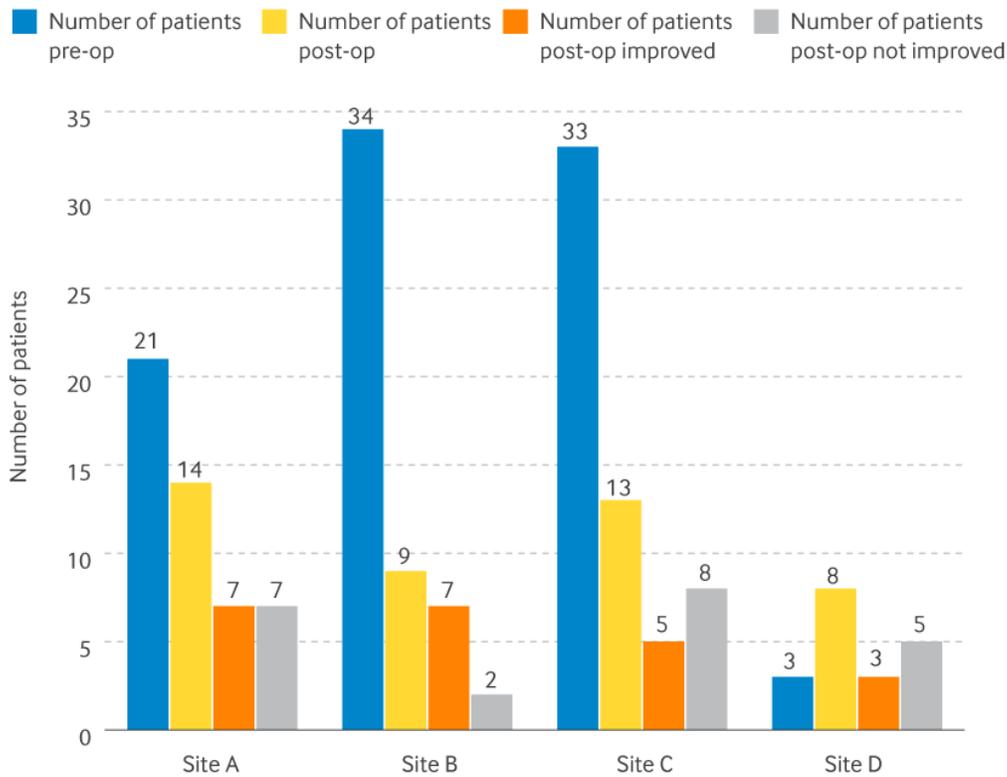
Site-by-Site Comparisons of IPUs

The IPUs were able to compare health outcome measures of VFSS and FS-IS of their respective populations with prevalence of the post-op binary outcomes (Figure 3) and noting overall post-op improvement of FS-IS across all sites (Figure 4).

FIGURE 3

Separate VFSS Outcomes Comparison at the Four IPU Sites

The separate VFSS outcomes of improved or not improved illustrates the ability to compare prevalence of postop binary outcomes of the sites against each other. The preop and postop patients are not paired results. The number of patients who improved postoperatively was not consistently more prevalent in our population groups across sites. The authors believe this reflects the unpaired results and low sample sizes primarily, but they also recognize treatment of this disease is challenging with both anatomic and physiologic factors at play that may not be resolved simply with operative treatment.*



*Padia R, Coppess S, Horn D, Parikh S, Hoang J, Faherty A, DeMarre K, Johnson K. (2019). Pediatric dysphagia: Is interarytenoid mucosal height significant?: Anatomy Significance in Pediatric Dysphagia. *The Laryngoscope*. 129. 10.1002/lary.27535. <https://pubmed.ncbi.nlm.nih.gov/30671968/>

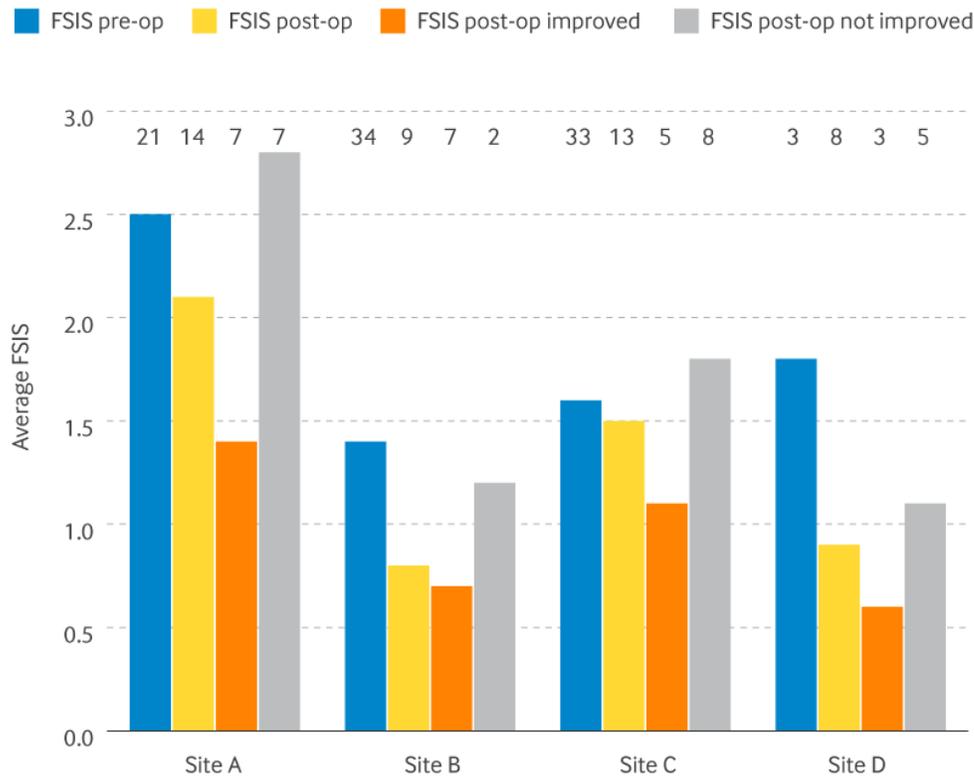
Source: The authors

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FIGURE 4

FS-IS Average Outcomes at the Four IPU sites

The separate IPU outcomes comparison illustrates the respective IPUs' ability to collect and compare cohorts of patients across preop, postop, and further stratified based on the VFSS gold standard of binary postop improved and not-improved. The preop and postop patients are not paired results.



Source: The authors

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The IPUs were also able to compare the post-op patients' FS-IS as grouped based on binary VFSS outcomes, noting the positive correlation of FS-IS with VFSS indicating post-op improvement of swallow at all sites (Figure 4).

When further studying the stratified outcomes of the sites as grouped by VFSS improved or not-improved, two of the four sites showed worsening FS-IS in their post-op not-improved groups (Sites A and C) (Figure 4).

Costs of Aerodigestive Care

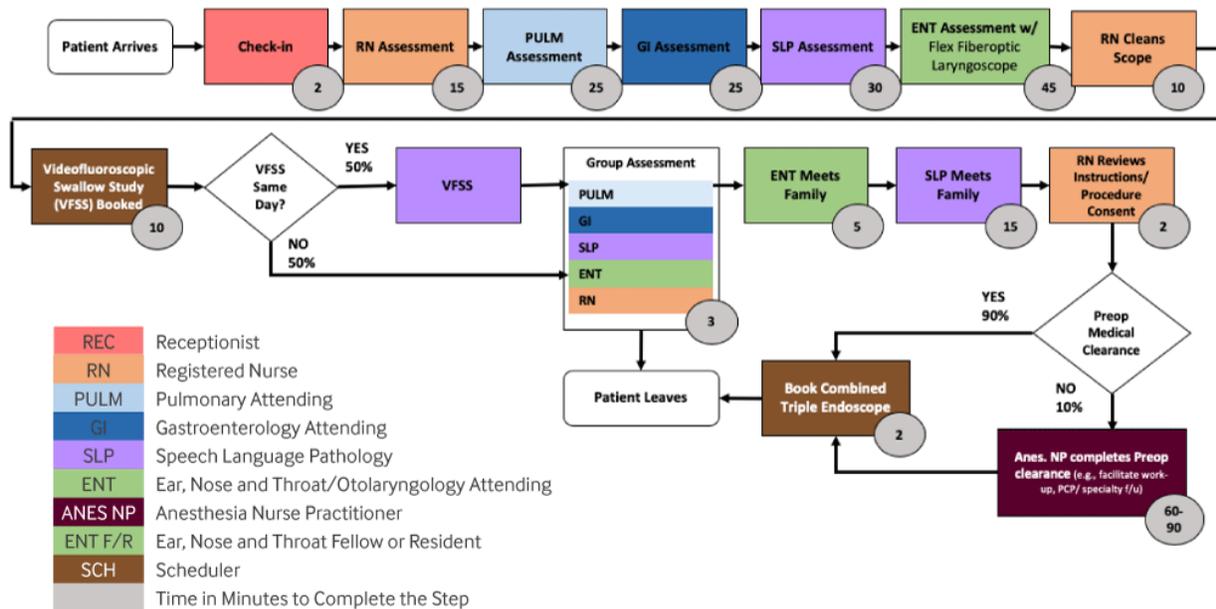
Process Mapping

Figure 5a shows the process map for initial review of a potential patient at Site A. (Other IPU sites used similar processes.) After check-in, the patient was seen sequentially by the pulmonologist, gastroenterologist, SLP, and ENT, followed by a brief, 3-minute visit during which the physicians assessed the findings and developed an action plan that was communicated to the family. After this visit, the patient and family went through preparations and scheduling for the endoscopy visit.

FIGURE 5A

Site A Process Map for Patient's Initial Visit to Airway Center

The map illustrates the flow of the patient at Site A through the multiple clinicians and staff (color-coded) during the patient's initial visit to the aerodigestive IPU. The number in the circle indicates the approximate time, in minutes, that the clinical or staff person spends with the patient at that step.



Source: The authors

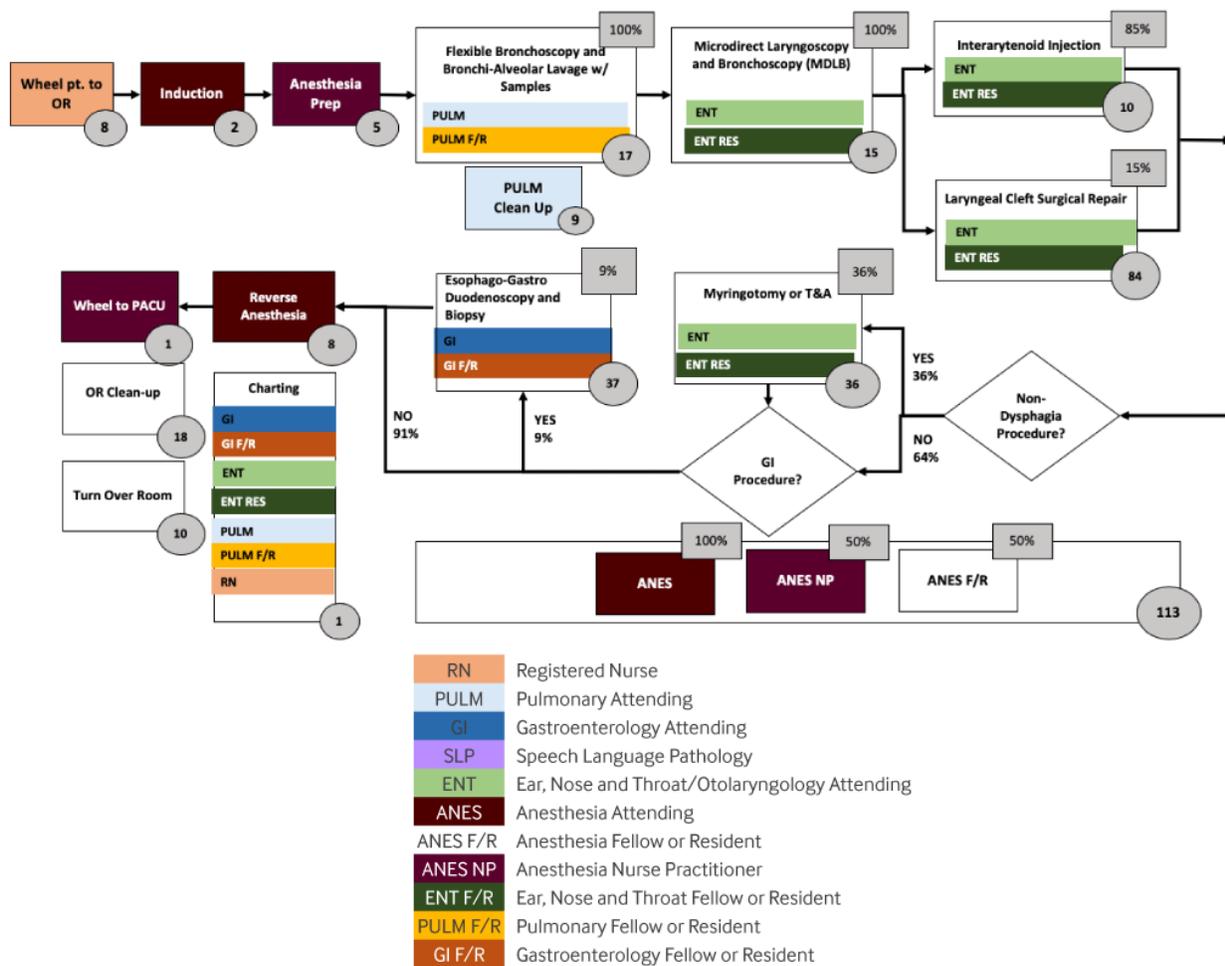
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Figure 5b shows the process map for the endoscopy procedure at Site B. It demonstrates common threads and variations across a dozen or more steps that constitute integrated care delivery in a single operating room (or procedure suite) for the diagnosis and management of pharyngeal-phase dysphagia. As each proceduralist sequentially performs their subspecialized roles, the child is maintained under a single anesthetic by an anesthesia care team.

FIGURE 5B

Endoscopy Procedure at IPU Site B

The map illustrates the process flow as each specialist sequentially performs a procedure while the patient is maintained under a single anesthetic by the anesthesia care team.



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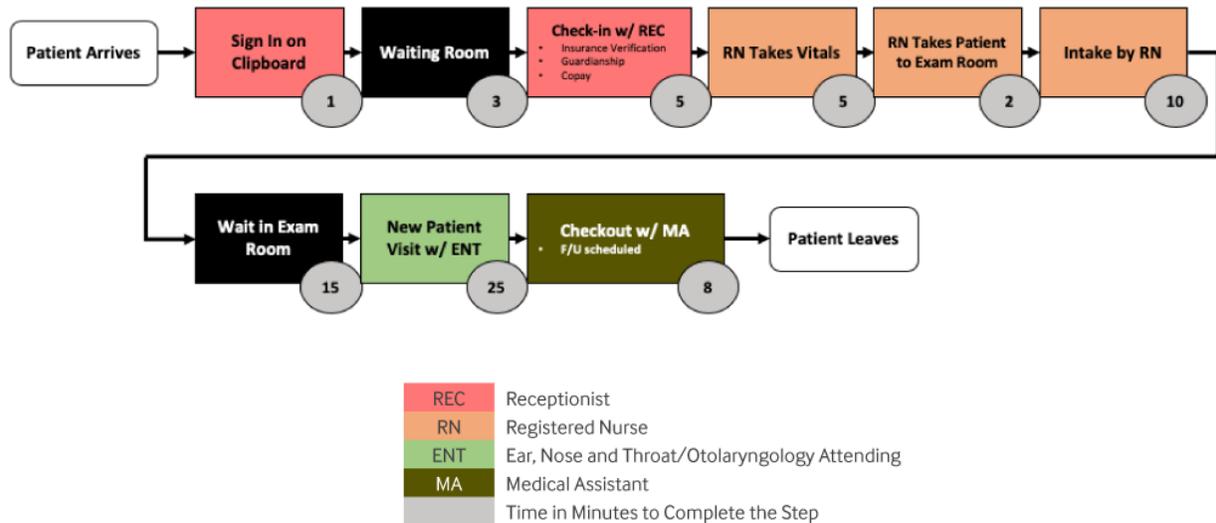
Site B's map shows a built-in option for definitive repair of a laryngeal cleft. This improves efficiency by performing comprehensive diagnosis and management under a single anesthetic. One risk of this approach — not reflected on the process map — is performing a delicate laryngeal operation on an inflamed airway caused by an aerodigestive dysfunction. The other three IPUs assessed aerodigestive dysfunction after receiving the results from various studies and biopsies. The damaged airway would then be repaired, along with any other required interventions issues, during a second anesthetic setting. Without the detailed process-mapping for the TDABC analysis, such inter-site variation when treating the same condition would not have been visible and discussable.

Figure 6a shows the diagnostic ear, nose, and throat (ENT) visit performed at non-IPU Site E. The diagnostic care phase required separate process maps for the gastrointestinal (GI) visit, pulmonologist visit, and SLP and swallow visit. This set of visits typically occurred over a period of 14 days; contrast that with the diagnostic visit that lasted less than half a day at the IPU sites.

FIGURE 6A

Site E Process Map for the Initial Diagnostic ENT Visit

The map illustrates the flow of the patient at non-IPU Site E through the multiple clinicians and staff during the patient's initial ENT diagnostic visit. The number in the circle indicates the approximate time, in minutes, that the clinical or staff person spends with the patient at that step. Additional process maps (not shown) were developed for GI, pulmonary, and SLP and swallow diagnostic visits.



Source: The authors

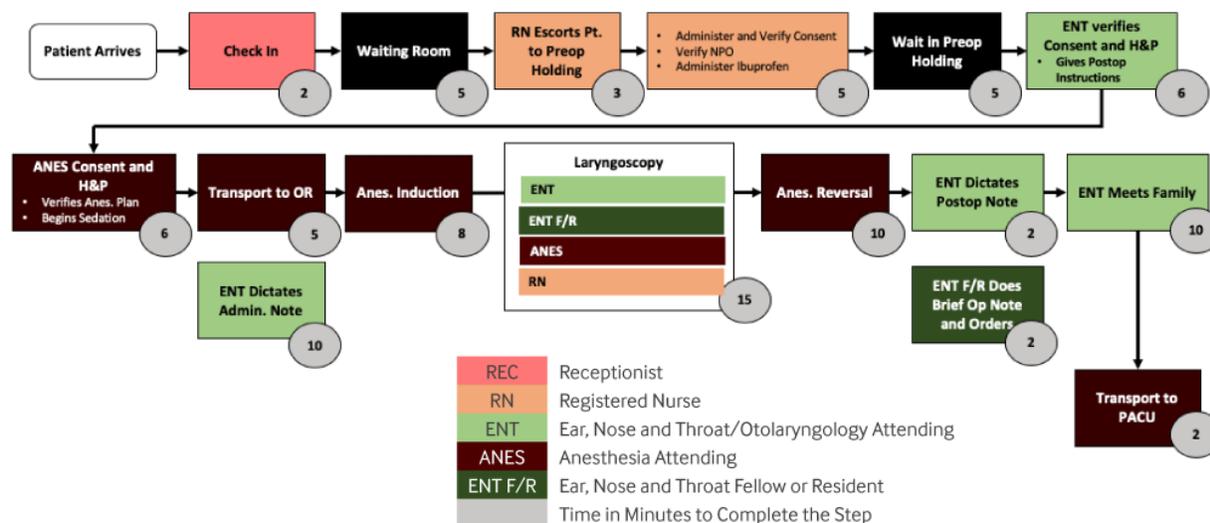
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Figure 6b shows the process maps for the separate procedural visit performed by the ENT at non-IPU Site E. As with the diagnostic visit comparison, the patient could have two additional and separate procedures, performed by a pulmonologist and gastroenterologist, over a period of 1 month, with each one requiring a separate anesthetic administered to the patient.

FIGURE 6B

Process Map for the Site E ENT Procedural Visit

The map illustrates the flow of the patient at non-IPU Site E through the multiple clinicians and staff during the patient’s ENT procedural visit. The number in the circle indicates the approximate time, in minutes, that the clinical or staff person spends with the patient at that step. Additional process maps (not shown) were developed for GI and pulmonary procedural visits.



Source: The authors

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Cost and Time Comparisons

Each of the IPU sites calculated its own CCRs for the various clinical and administrative personnel involved in the patient’s care cycle. To preserve confidentiality of each site’s cost structure, Harvard Business School researchers calculated a blended rate — a simple arithmetic average — of each site’s CCR. In this way, the cost comparisons across the sites reflected the process efficiencies and differential skill levels (i.e., task downshifting) used to perform similar processes at the four sites but not differential pay levels across them. The blended CCRs were also used to cost out the process maps at the two non-IPU sites.

Table 1 summarizes the total costs incurred at four IPU sites (A-D) using identical personnel CCRs (calculated as the simple average of personnel CCRs at sites A-D). This calculation allows the variation in total cost to be attributed solely to the efficiencies of personnel at the four sites and the different mix of skill levels each site used to treat patients. The comparison enables a site to identify and adopt best practices at lower-cost organizations.

Figure 7 shows the detailed costs of the top 10 personnel types at the six sites, calculated with identical CCRs — the average of personnel CCRs at the four IPU sites.

Table 1. Total Costs at Four IPU Sites

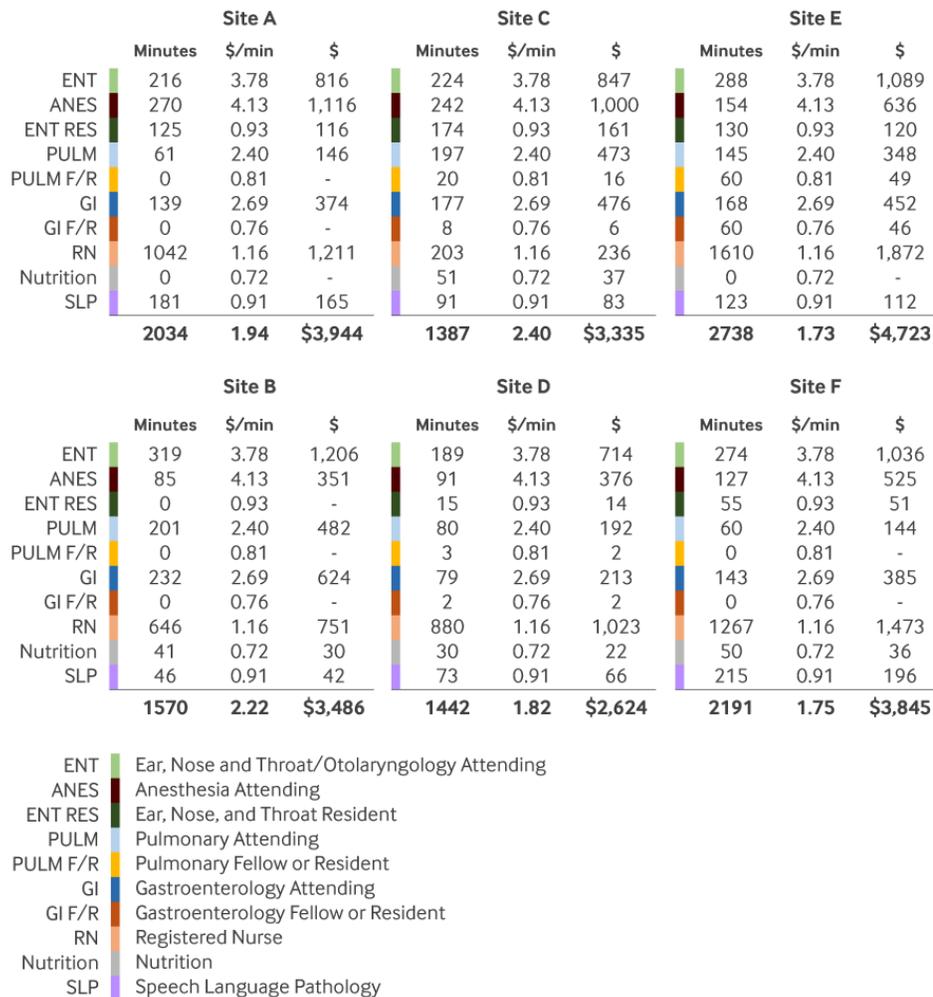
Site	Total Cost.
A	\$6,700.
B	\$5,700.
C	\$4,100.
D	\$4,300.

Source: The authors.

FIGURE 7

Comparison of 10 Most Expensive Personnel at the Six Sites Using the Same Average \$/minute for Each Personnel Type

This figure compares the total cost of each personnel type used to treat patients at the four IPU sites (A–D) and the two non-IPU sites (E and F). Using the average \$/minute for each personnel type eliminates cost differences due to different compensation levels at the six sites. The differences in individual and total cost (\$) shown for the top 10 personnel types reflect differences in efficiencies and skill mix at the six sites.



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Figure 7 documents how Site D achieved the lowest costs of the four sites. It used more lower-cost nursing (LPN/RN) time (880 minutes) relative to the time (439 minutes) of the four most expensive personnel types: ENT, anesthesia, pulmonary, and GI physicians. Site D's ratio of nursing to physician time was 2.00 while Site C's ratio was 0.24, explaining why Site D had the lowest average cost per minute (\$1.82) and Site C had the highest (\$2.40) among the four IPU sites. This finding suggests an opportunity for other sites to learn from Site D how to accomplish task downshifting from physicians to nurses.

Site A's personnel costs were 13% higher than the second-highest site (B) even though it had the second-lowest use of the four expensive physician types (686 minutes) and the second-lowest average cost per minute (\$1.94). Its high costs can be attributed to having far more total number of LPN/RN minutes (1,042) than any of the three other IPU sites. Site A has begun a study to identify potentially inefficient use of nurses for integrated aerodigestive care.

After studying the process maps and cost data, lead physicians at the IPU sites launched several continuous improvement projects. These included the following: (1) one clinic rearranged its layout to enhance flow, communication, and efficiency; (2) an IPU that had not included a GI specialist decided to add this specialty after seeing the efficiencies realized at the other sites with GIs embedded in the IPU; (3) clinics reduced redundant administrative, nursing, and support costs by, for example, task downshifting from a nurse to a medical assistant to room patients, and by adding a patient care coordinator to increase efficiency, reduce extra testing, and improve the patient experience; and (4) Site A redesigned the postoperative visit so that only the SLP saw the children, with some task downshifting from the SLP to the clinic's medical assistant. This innovation made clinical sense because the main tasks during the postoperative visit were to assess swallow function and work on therapeutic swallow strategies. The change reduced overall cost of care by 3% and allowed the other services to see a greater volume of new patients.

“ *Project teams at each site developed the process maps to capture every interaction between the patient and the clinic during the complete care cycle.* ”

The comparisons between the four IPU sites and the two non-IPU sites were the most interesting. For the four physician types, the two non-IPU sites had average total times of 680 minutes, which was lower than the average physician time of 701 minutes at the four IPU sites. This somewhat confirmed the alleged inefficiency of grouping physicians into an IPU rather than have them do their specific tasks independently. But the less than 5% difference does not support anecdotal suggestions of much greater variation in the number of patients seen per physician. And this apparent savings was dwarfed by the much higher use of LPN/RN time at the non-IPU sites (average of 1,439 minutes) compared to the average (693 minutes) at the IPU sites. Rather than have one nursing team working with an integrated physician team, the non-IPU sites had separate nursing teams for each physician. This led the average total personnel costs of the non-IPU sites to be 28% higher than the average of the four IPU sites (\$4,284 versus \$3,347). (The far higher use of lower-cost nurses also explained the low average cost per minute at the two non-IPU sites.)

None of these figures include the savings in hospital space and administrative costs of a single IPU rather than supporting completely separate clinics. And the far higher personnel costs of non-IPU sites does not include the much higher costs and risk imposed on the child and parents when they made separate visits, with separate procedures performed, on many more days during the treatment cycle.

The analysis demonstrates the clear cost advantage that aerodigestive IPUs have over a non-IPU system. The lead clinicians unanimously stated that the nurse coordinator was most important to the success of the IPU. The study enabled them to persuasively justify the role for mid-level providers, such as nurse coordinators, to their departments and hospitals.

The IPU also offers compelling benefits, which we did not quantify, to the child and family of significantly fewer office and operative visits requiring anesthesia. It also illustrates the considerable opportunities for innovations in process improvement and task downshifting when comparing process maps and costs across similar IPU sites.

Challenges and Limitations of Aerodigestive IPUs

When first establishing an aerodigestive IPU, each site thought that it could be difficult to coordinate between different subspecialties, that revenue losses could occur if fewer patients would be seen during the same time period, and that an extra person, a nurse coordinator, would be needed to streamline patient flow through the IPU and serve as the interface between clinicians and the patient. The IPU's accountability to the hospital, specific department or group of departments, or the clinicians themselves for revenue losses or additional costs was unclear.

There was also concern about implementing a TDABC model for measuring the costs in the IPU. Certain institutions had more experience than others with process mapping at a divisional or departmental level; there was also variation across the sites in clinicians' comfort levels about tracking the duration of a practitioner's time with patients, as well as whether such times could be accurately tracked, recorded, and validated. Once the process mapping and timing got started, these concerns were assuaged and the clinicians felt that the TDABC approach was a clear and valid process.

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The analysis demonstrates the clear cost advantage that aerodigestive IPUs have over a non-IPU system.”

The initial process maps at the four IPU institutions revealed small variations in the sequence of operations and mix of personnel during the cycle of care. These apparently subtle differences became amplified when CCRs were applied to the process maps to calculate the total cost of care at each institution. The cost comparison across four IPUs, all delivering about the same patient outcomes, reflected how each institution resolved the tension between a physician's desire for more experienced, higher-trained, and better-compensated staff versus a higher-cost burden at each institution.

The most difficult aspects of building VBHC models were (1) agreeing across centers on the validated and quantifiable outcome measures to choose and then how to implement their measurement across the care cycle, and (2) obtaining clean and accurate cost data from the hospital's finance function. The clinicians concluded that overcoming both difficulties proved doable and that, once accomplished, doing so would allow future TDABC and VBHC studies to be executed more easily.

Parents felt that while they benefited greatly from receiving a unified diagnosis in one setting, they wanted more up-front messaging about the extended visit time to see all providers.

We studied the processes and costs for aerodigestive IPU care for dysphagia only. A comprehensive study of aerodigestive IPU care would require analysis of diverse aerodigestive diseases where breathing problems affected feeding, feeding problems affected breathing, and upper-airway conditions affected the lower airway. The analysis would need to assess integrated aerodigestive care costs for treatments ranging from dietary changes to complex surgical reconstructions. Depending on contractual reimbursements for services rendered, the profitability of integrated aerodigestive care will vary across these diverse treatments. Moreover, the analysis should eventually include the opportunity costs (or lost revenues) from seeing simpler and less complex patients during an aerodigestive IPU session.

With only a small sample of IPU and non-IPU sites studied, the observed differences in efficiencies and task downshifting among the IPU and between the IPU and non-IPU sites could not be statistically tested or validated. Some of the observed differences could turn out to be statistically insignificant had we conducted the same analysis on a much higher number of IPU and non-IPU sites.

For the study's outcomes measures, the IPU sites collected population means at the various time points. They did not follow individuals longitudinally, which would have allowed better comparisons on the efficacy of care based on VFSS pre-op and post-op improved or not improved. Also, while the aggregate number of patients across IPU sites is relatively large to assess aggregate outcomes, the individual site sample sizes are relatively small and do not necessarily represent statistical significance. The processes for referral of patients into care by the aerodigestive IPU sites are different at each site, which could introduce selection bias of patients with varying baseline severity of disease and intervention requirements. Adverse selection was also possible in the patients who received the intervention of surgical augmentation, as the sites had different processes to determine which patients would benefit from surgical augmentation.

“ *TDABC demonstrates the benefits of having health care employees operate at the highest level allowed by their licensure.* ”

The study assessed binary improvement of swallow on VFSS with advancement in diet, which may involve a shared clinical decision with the provider and child's family and other factors extraneous to the mechanics of swallow on VFSS. This determination is also made by different providers at different institutions, raising the risk of variability in practice when comparing institutions

against each other. Future studies with matched data will allow an improved ability to track how significantly individual patients improve with specific interventions.

We used TDABC to quantify the personnel and equipment costs at the sites. We did not measure the costs of space, consumables (e.g., gloves), or inexpensive equipment whose collective costs would be less than 5% of personnel costs. Their omission should not affect the comparison across sites. Our analysis did not include administrative and facilities costs. Hospitals differ in how they allocate overhead, and none of the existing methods accurately traced these indirect costs to patient treatments. Qualitatively, these administrative and other indirect costs are likely to be higher at the non-IPU sites, which have separate clinics for each of the aerodigestive specialties and, therefore, replicate functions such as registration, insurance verification, billing, and office management. One IPU site has an entire wing dedicated to its hospital's several multidisciplinary IPU clinics, such as for aerodigestive and hemophilia. The space has been designed to optimize the aerodigestive team's work, communication, and huddles (brief, focused meetings of clinicians).

TDABC, while more accurate than traditional hospital costing systems, requires more time to implement, including the time it takes for physicians and nurses to document and validate process maps and process times. One IPU site is exploring the use of RFID technology and an electronic dashboard to automatically and accurately record the quantity of time a patient spends with each clinic and staff person during a care cycle. If successful, such technology will reduce the effort required to develop process maps and estimate process times, in addition to providing real-time information that could improve care.

What's Next for IPUs and TDABC

Providing aerodigestive care in the context of an IPU appears to be economically advantageous. In IPUs, the coordinated and integrated care was less expensive than it was in facilities offering notionally separate care. This care in the IPU also improved patients' Tier 1, Tier 2, and Tier 3 health outcomes. Both components of the value equation — outcomes and cost — improved under IPU care delivery.

In the setting of four large hospital systems, we were able to successfully utilize TDABC to drill down into the costs of delivering care for a specific disease (i.e., dysphagia). TDABC provided the data necessary to analyze the process of care, and the implementation of TDABC in each of these institutions created a stronger focus on process improvement and sharable information across institutions trying to improve the value of their care. There is a range of per-minute costs of personnel providing patient care in an aerodigestive care IPU. TDABC shines light on the inefficiency and costliness of having physicians and surgeons entering orders, performing billing, and documenting their own encounters to reduce full time-equivalents in an IPU. In other words, TDABC demonstrates the benefits of having health care employees operate at the highest level allowed by their licensure.

Future steps include the measurement of costs and patient outcomes for more diagnosis-specific, multidisciplinary IPU centers, and comparing the outcomes and costs to those achieved at comparable institutions that continue to deliver care in the traditional, specialty-focused manner.

Success with a value-based care model requires changing reimbursement so that the IPU and its hospital are paid adequately when value is delivered. A value-based bundled payment to an aerodigestive IPU would further its mission of producing better patient outcomes at lower cost. For the IPU to negotiate a bundled price that includes a reasonable margin, it must understand its total resource costs — including personnel, equipment, space, and consumables — to deliver that care.

TDABC provides the tools to quantify resource costs and the visibility to understand the quantity and mix of resources being used, including the cost of unused capacity. An accurate picture of total resource cost across the patient care cycle enables clinicians and administrators to make data-driven decisions on appropriate use of mid-level personnel, technology, and quality improvements to optimize costs while delivering improved patient outcomes.

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[Study Sites](#)

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