Orientation in Perpetuity: An Online Clinical Decision Support System for Surgical Residents

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ABSTRACT

Background: Limiting variability is an essential element to improving quality of care. Frequent resident turnover represents a significant barrier to clinical standardization. Trainees joining new surgical services must familiarize themselves with the guidelines and protocols that direct patient care as well as their learning objectives and expectations. A clinical decision support system (CDSS) is a dynamic, searchable electronic resource intended for use at the point of care. The CDSS can provide convenient and timely access to relevant information for residents, allowing them to incorporate the most up-to-date protocols and guidelines in their daily care of patients. The objective of this quality improvement intervention was to determine the objective rate of CDSS utilization and its subjective value to residents.

Materials and methods: An internally developed, web-based CDSS including essential, clinically useful documents was created for use by trainees on a busy pediatric surgery service. A standardized orientation was provided to each resident and fellow on joining the service, complemented by a summary card to be attached to the trainee’s ID badge. CDSS usage was monitored using web analytics. Trainees who rotated before and after the CDSS launch were surveyed regarding attitudes toward clinical resources and confidence in patient management.

Results: Documents published to the CDSS included 33 clinical guideline documents and 207 additional educational and support files including reference materials from service orientation were made available to trainees and staff. Goals for resident usage were established by evaluation and adaptation of early traffic patterns. Analysis of web traffic collected over 14 consecutive months revealed utilization above target levels, with 4.0 average weekly page views per trainee (IQR: 1.6-5.6). A total of 60 survey responses were received (54% of trainees invited); majorities of rotating trainees and survey respondents were trainees in general surgery and most were interns. Mean composite scores reflected a trend toward improved satisfaction when seeking CDSM (before intervention 3.18 [SD 0.73], after intervention 3.92 [SD 0.70], range 1-5) which was statistically significant (P = 0.005).

Mean scores also improved across five of six components of the composite score (mean improvement 0.75, range: 0.53-0.92), four of which were statistically significant (P = 0.001-0.038). Most (59%) respondents reported that they used the CDSS frequently.

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Conclusions: Convenient access to a CDSS resulted in greater than expected utilization as well as higher resident satisfaction with and confidence in materials provided. A CDSS is a promising tool offering quick access to high-quality information in challenging trainee environments.

Methods

Data source and informatics

A dedicated website was designed and deployed using an off-the-shelf collaboration platform (SharePoint 2010; Microsoft Corporation, Redmond, WA). Existing clinical guidelines were posted on the site and made available throughout the hospital. Several ancillary measures were undertaken to minimize barriers to CDSS utilization. These included 1) an orientation session conducted by the project leader introducing the CDSS and demonstrating how to access it; 2) distribution of reference cards attached to the resident’s hospital ID badge with directions on CDSS access; 3) the addition of a Domain Name Service alias, allowing users to access the CDSS using a three-character “shortcut” web address. Several design enhancements were also added to the CDSS to streamline access to useful content. These included 1) the use of document type classification fields, combined with filtered lists that present only clinical guidelines; 2) a list of most frequently accessed documents on the site’s home page; and 3) a flattened organizational structure (limiting the complexity of hierarchical organization of documents in “folders”).

The CDSS was then linked electronically with cloud-based analytics (Google Analytics, Google LLC, Mountain View, CA) to enable traffic to the site to be monitored over time. Total browsing sessions (in which a user accessed the CDSS and viewed one or more pages) as well as total page views were collected and analyzed in weekly intervals. A 4-wk moving average was used to adjust for predicted variation in CDSS web traffic as new residents rotated onto the service. Patterns observed early after CDSS deployment were adapted into utilization goal thresholds. Traffic analysis was restricted to sessions that accessed clinical content. Online surveys were conducted using trainee volunteers who rated their interactions with clinical guidelines, their satisfaction with that process as well as their confidence in clinical decision-making. Survey data were collected anonymously and respondents indicated agreement with statements describing the experience of seeking information to guide clinical decisions. Responses were scored on a five-point Likert scale.

Study population

Residents and fellows rotating on the pediatric surgery service from nine training programs were surveyed. They were
divided into two groups. The preintervention cohort completed rotations before the introduction of CDSS (August 2016—November 2016) and the postintervention cohort completed rotations afterward (December 2016—March 2018). All trainees were invited via email to complete the survey, with the preintervention cohort receiving invitations at the start of the study and residents in the postintervention cohort invited shortly after completing their assigned rotation. Fellows participating in the postintervention cohort received an invitation between their second and third month of exposure to the CDSS.

Statistical analysis

Pearson’s chi-squared test was used for comparison of categorical variables and Kruskal–Wallis rank sum test was used for univariate comparisons of survey scores. Significance was defined as $P < 0.05$. All analyses were conducted in R 3.4.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

The website was launched in September 2016 and made available to trainees starting in December. A total of 33 clinical guideline documents and 207 additional educational and support files (e.g., textbook chapters, call schedules) had been posted to the site at that time. An additional twelve guideline documents were posted over the ensuing 14 months. Documents focused on clinical management in pediatric surgery, with guidance relating to specific conditions (e.g., pyloric stenosis), procedures (e.g., sleeve gastrectomy), interservice coordination (e.g., acute pain service consultation), and perioperative care (e.g., bowel prep).

A total of 110 trainees rotated on the pediatric surgery service during the study period, and included interns (PGY-1, $n = 59$), junior residents (PGY-2, $n = 2$), senior residents (PGY 3–PGY-4, $n = 40$), and clinical fellows (PGY-6–PGY-10, $n = 9$) with one fellow rotating during both pre- and post-intervention periods. Residents were most frequently from general surgery programs, with plastic surgery, oral and maxillofacial surgery, urology, and pediatrics also represented. Resident makeup did not significantly differ between pre- and post-intervention periods, with the exception of rotating pediatrics residents, who were not included in the preintervention group. Median length of rotation on service was 29 d (range 19-730 d) and the mean weekly complement of trainees on service during the intervention period was 9.9 (range: 4-13). Sixteen of 37 trainees (43%) in the preintervention cohort completed surveys as did 44 of 73 (60%) in the postintervention cohort. Resident makeup of survey respondents was similar to rotating residents overall with no statistically significant differences in the pre- and post-intervention cohorts and 50% reporting rotations of only 1 month. Table 1 summarizes the characteristics of the pre- and post-intervention groups.

Analytics captured 772 unique browsing sessions comprising a total of 2696 page views during the intervention period (approximately 14 months). A weekly mean of 11.5 sessions (40.2 page views) were logged; when normalized for trainee complement, 1.2 weekly sessions (4.0 page views, IQR: 1.6-5.6) were logged per rotating trainee (Fig. 1). As expected, traffic was cyclic with regular “spikes” in traffic that roughly corresponded to the beginning of new trainee rotations—with rotations most commonly lasting 4 wk. The 4-wk moving average of weekly page views per trainee was maintained above the goal rate of one. Analysis of page depth revealed a steady decrease in mean page depth from a baseline of 4.13

| Table 1 – Rotating trainee and trainee survey respondent characteristics. |
|--------------------------------------------------|------------------|------------------|------------------|------------------|
| **Trainees**                                      | Preintervention  | Postintervention | Total            | **P**            |
| Rotating on pediatric surgery service             | N (%)            | N (%)            | N (%)            |                  |
| General surgery*                                 | 33 (89)          | 59 (81)          | 92 (84)          | 0.150            |
| Surgical subspecialty                            | 4 (11)           | 7 (10)           | 11 (10)          |                  |
| Pediatrics                                       | 0 (-)            | 7 (10)           | 7 (6)            |                  |
| Intern                                           | 22 (59)          | 37 (51)          | 59 (54)          | 0.159            |
| Senior resident                                  | 14 (38)          | 26 (36)          | 40 (36)          |                  |
| Fellow                                           | 0 (-)            | 9 (12)           | 9 (8)            |                  |
| Total (%)                                        | 37 (34)          | 73 (66)          | 110 (100)        |                  |
| Responding to survey                             | N (%)            | N (%)            | N (%)            |                  |
| General surgery*                                 | 18 (95)          | 30 (73)          | 48 (80)          | 0.125            |
| Surgical subspecialty                            | 1 (5)            | 5 (12)           | 6 (10)           |                  |
| Pediatrics                                       | 0 (0)            | 6 (15)           | 6 (10)           |                  |
| Intern                                           | 8 (42)           | 25 (61)          | 33 (55)          |                  |
| Senior resident                                  | 9 (47)           | 12 (29)          | 21 (35)          | 0.356            |
| Fellow                                           | 2 (11)           | 4 (10)           | 6 (10)           |                  |
| Total (%)                                        | 19 (32)          | 41 (68)          | 60 (100)         |                  |

*Includes fellows in pediatric surgery, surgical critical care, minimally invasive surgery, colorectal surgery, and bariatric surgery.
pages per session to a sustained average below 3, exceeding the project goal (Fig. 2).

Survey response data also suggested high utilization with 59.1% of trainees in the postintervention group reporting regular use of the CDSS. Postintervention responses also improved for five of six questions that assessed respondent attitudes regarding finding clinical materials and confidence making clinical decisions. Specifically, the scored changes suggest that postintervention cohort respondents were better able to find clinical materials that were relevant (3.29 to 3.86, +0.57), current (3.10 to 3.97, +0.88), and consistent and complete (2.90 to 3.74, +0.84). Furthermore, they were able to find information more quickly (2.90 to 3.83, +0.92) and felt more confident in their decisions (3.52 to 4.06, +0.53). Statistically significant changes were identified for three of the five improved scores (current materials, \( P < 0.001 \); quickly find materials \( P = 0.027 \); confidence in decisions \( P = 0.030 \); and complete/consistent information, \( P = 0.002 \)) as well as for a composite score (3.18 to 3.92, +0.74; \( P = 0.002 \)). A single response (scored on a reverse Likert scale and endorsing confusion when obtaining information) worsened between the two intervals (3.38 to 3.94, +0.56), and this difference was statistically significant (\( P = 0.049 \)). Survey results are summarized in Table 2.

**Discussion**

A well-curated, fully searchable document repository can be an effective CDSS aiding trainees in the daily care of patients on a busy service. Trainees consumed content from this novel resource at a sustained rate above our project goal. Survey data indicate broad acceptance of and appreciation for this tool. This stands in stark contrast to another common solution to the challenge of resident orientation. The “service manual” is typically a single document, compiled at regular intervals and provided to rotators as hard copy on arrival. While both CDSS and service manual content at this institution substantially overlap, preparation and maintenance of a service manual is simultaneously resource-intensive and insensitive to changes in practice. Clinical guidance evolves frequently, and a monolithic document typically entails a protracted revision cycle. Whereas service manuals provided to trainees have previously been poorly utilized, this CDSS has become a focal point for knowledge transfer. In response, other clinical departments at our institution are exploring parallel projects based on the same design.
One hundred ten trainees in 14 months spent a median of only 29 d on the service, highlighting the importance of clinical continuity amid a rapidly-shifting complement of clinicians. Our institution provides pediatric surgical rotations to trainees from four general surgery, one pediatrics, and several other surgery residency programs (including otolarlynology, plastic surgery, oral maxillofacial surgery and urology) as well as outside rotators from across the county. Only pediatrics residents and surgical fellows are primarily assigned to our facility, with the remainder rotating for relatively short intervals (1 to 3 months). Simultaneously familiarizing each new trainee with the functional elements of the clinical service, the institutional protocols and the unique needs of the pediatric patient presents significant challenges for which CDSS offers unique advantages. The ability to categorize and aggregate materials as an “orientation package,” the option to delegate content curation and revision to local experts and the immediate availability of the online materials in the working environment were likely contributors to the improvement in survey responses. The only negative trend in trainee responses indicated increased agreement with the statement “I am confused about how to obtain needed information” when “seeking information to guide clinical decisions for Pediatric Surgery patients.” This may reflect the introduction of a new and relatively unfamiliar system of delivery (a specialized web site), which represented one additional new element in the clinical environment at our center. Alternately, this may be an artifact of the scoring system and consequent confusion on the part of respondents. All other questions in the section addressing information gathering were scored with high numeric values indicating “positive” responses, whereas this question associated a positive outcome (less confusion) with lower values. Statistical significance in the positive changes in the survey composite score as well as attainment of our objective goals of site utilization and minimal page depth were indicative of overall success in this Quality Improvement initiative.

CDSSs have been the subject of interest to both policy makers and investigators as a potential means to ensure quality patient care and contain costs. CDSS adoption was introduced (and subsequently withdrawn) by the Center for Medicare and Medicaid Services as a mandatory component of Meaningful Use under the Medicare Access and CHIP Reauthorization Act of 2015. A systematic review conducted by Bright and colleagues examined 148 studies of CDSSs across a variety of health care environments and concluded that such systems generated improvements in directing clinicians to appropriate treatments, preventive care services and clinical studies. These investigators nonetheless found limited evidence for improved clinical outcomes, cost containment or operational efficiency. A more recent review of inpatient care by Varghese, et al. describes highly variable effects with 70% of studies reporting some improvement in patient outcomes, and more substantial prevention of harm only for select disease entities.

Several barriers exist that can impede effective utilization of CDSSs, including user awareness, interruption in normal workflow, and lack of perceived relevance of information. Design and implementation decisions attempted to address specific barriers and contributed to the success of this quality improvement project. The system described here was deployed as a free-standing resource rather than as an integrated component within the electronic medical record. This ensured that use of the resource would not interrupt normal workflow and that departmental stakeholders could maintain direct control of the content. Without the necessity to delegate content updates to our Information Services department, deployment of and revisions to essential materials directing patient care were quickly accomplished. The reconfiguration of the hospital Domain Name Service server to add an alias address (in this case “SUR” was used to denote “Surgery”) was another crucial factor. Aliases are supported in the Domain Name Service protocol, and trainees described this a welcome efficiency measure, given the difficulty of navigating to the CDSS from the hospital “intranet” site with consequent increasing page depth. The open access to the site by all users authenticated on the hospital network also contributed to efficient consumption of CDSS-hosted materials and permitted the surgical team to share information with collaborating clinical services. Finally, leveraging a commercial web-based collaboration platform that was already in use at our facility greatly reduced the time required to design and deploy the site and entailed no additional infrastructure, licensing or programming costs to the department.

Limitations of this study include the constraints of the analytics platform, which was not configured to track browsing activity on an individual level. It is therefore difficult to quantitatively attribute CDSS content consumption to

| Table 2 – Change in survey scores between preintervention and postintervention period. |
|-----------------------------------------------|------------------|------------------|-----|
| Respondent agreement: When seeking information to guide clinical decisions... | Preintervention | Postintervention | P |
|                                           | Mean [SD]        | Mean [SD]        |    |
| Can find relevant materials               | 3.29 [0.90]      | 3.86 [0.81]      | 0.076 |
| Can find current materials                | 3.10 [0.83]      | 3.97 [0.89]      | <0.001 |
| Can quickly find materials                | 2.90 [1.09]      | 3.83 [0.98]      | 0.027 |
| Feel confident in decisions               | 3.52 [0.93]      | 4.06 [0.80]      | 0.030 |
| Confused about obtaining information      | 3.38 [1.02]      | 3.94 [1.14]      | 0.049 |
| Information consistent and complete      | 2.90 [0.83]      | 3.74 [0.92]      | 0.002 |
| Composite                                | 3.18 [0.73]      | 3.92 [0.70]      | 0.002 |

Mean survey responses, scaled scores (1-5; 1 = never; 5 = always). Statistically significant P values are given in boldface.
trainees. We did not attempt to measure the effects of content consumption on adherence to the guidelines hosted on the CDSS, as our emphasis in this pilot was on feasibility and acceptability of the web-based system. Members of the pre-intervention group were identified from departmental records and many had completed the rotation several months prior to taking the survey. In addition to recall bias inherent to the survey methodology, it is possible answers in this group may be further biased by this longer interval. It is also possible that self-selection among survey respondents led to bias in the sampled data or that responses do not uniformly represent trainee experience due to gradual changes in CDSS content over the post-intervention period. Finally, we engaged multiple simultaneous measures to increase user engagement with and impact from our CDSS. It is not possible to quantify the impact of each, though anecdotal accounts suggest they were effective. This will be an important focus of inquiry as this system evolves.

The exploration and expansion of CDSS functionality is ongoing at our facility. In response to the most frequently-encountered user request, the collaboration platform will be made available to devices outside of the hospital network, which will permit CDSS access from smartphones and tablets. The system has also been expanded to establish and enforce faculty ownership and periodic review of the hosted materials. This process permits each document to be assigned an owner, a revision date, and a review interval. When the interval has elapsed, the system automatically alerts the owner via email and will send repeated prompts until the document is reviewed and (if necessary) revised. As noted above, a natural extension of this project would be to assess the effect of guidelines availability on resident performance, specifically adherence to directives described in CDSS documents.

This quality improvement project has demonstrated successful deployment of a web-based CDSS for use by a large and rapidly changing trainee complement at a pediatric tertiary care center. This innovation has provided timely guidance to residents and fellows in the surgical care of children and is valued by its consumers. These results suggest that such an intervention is a feasible and impactful means to support trainees at varying levels of seniority in delivering optimal care in a complex environment.

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Disclosure

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