JB&JS OPEN ACCESS

# Standardized Note Templates Improve Electronic Medical Record Documentation of Neurovascular Examinations for Pediatric Supracondylar Humeral Fractures

Jue Cao, MD, Ryan Farmer, MD, Patrick M. Carry, MS, Maria Goodfellow, BA, David C. Gerhardt, MD, Frank Scott, MD, Travis Heare, MD, and Nancy H. Miller, MD

*Investigation performed at Children's Hospital Colorado, Aurora, Colorado*

**Background:** Optimization of the electronic medical record (EMR) is essential to support the clinician and to improve the quality and efficiency of patient care. The present report describes the development and implementation of a standardized template that is embedded in the EMR and is focused on a comprehensive physical examination during the evaluation of pediatric supracondylar humeral fractures. We compared the completeness of physical examinations as well as the timing of detection and documentation of neurovascular injuries before and after implementation of the template. We hypothesized that the use of a template would increase the completeness of examinations and would lead to earlier documentation of neurovascular injuries.

**Methods:** A multidisciplinary quality-improvement task force was created to address neurovascular documentation practices for patients who underwent operative treatment of supracondylar humeral fractures. Following a series of formative and process evaluations, a standardized EMR template was implemented. Neurovascular examination documentation practices that were in use before (pre-template group, n = 224) and after (template group, n = 300) the implementation of the template were compared. Logistic regression analyses of the 2 groups were used to compare the likelihood of a complete neurovascular examination and the timing of neurovascular injury identification.

**Results:** There was significant improvement in the documentation of the vascular (odds ratio [OR], 70.7; 95% confidence interval [CI], 39.5 to 126.6; $p < 0.0001$), motor (OR, 17.6; 95% CI, 9.5 to 32.7; $p < 0.0001$), and sensory (OR, 23.9; 95% CI, 12.9 to 44.4; $p < 0.0001$) examinations in the template group. Neurological injuries were more likely to be identified preoperatively in the template group compared with the pre-template group (OR, 6.8; 95% CI, 1.7 to 27.1; $p = 0.0067$).

**Conclusions:** The incorporation of a standardized template in the EMR improved the completeness and timing of documentation of neurological injury. Standardized EMR templates developed by a clinically driven multidisciplinary task force have the potential to improve the quality of clinical documentation and to ease communication among providers.

**Level of Evidence:** Level III. See Instructions for Authors for a complete description of levels of evidence.

Electronic medical records (EMRs), first implemented in the 1960s, were quickly recognized as a revolutionary data-communication system that could improve patient safety as well as the quality and efficiency of patient care[1]. Numerous EMR systems have been developed since that time, and such systems have become increasingly robust in their capabilities to capture and organize patient-care data. The incorporation of semi-structured notes and diagnosis-tailored templates in the EMR can improve the accuracy, organization, and completeness of the data

**Disclosure:** The study was supported in part by NIH/NCRR Colorado CTSI Grant Number UL1 RR025780. On the **Disclosure of Potential Conflicts of Interest** forms, *which are provided with the online version of the article*, one or more of the authors checked "yes" to indicate that the author had a relevant financial relationship in the biomedical arena outside the submitted work (http://links.lww.com/JBJSOA/A21).

Disclaimer: Contents are the authors' sole responsibility and do not represent official NIH views.

collected[2,3]. However, as our health system becomes more electronically dependent, concerns regarding the successful implementation and optimization of a standardized template have been raised as a result of the competing interests of information technology professionals, hospital administrators, and clinicians[4].

Our institution, a tertiary pediatric referral center, implemented an EMR system in 2003. Over the past 10 years, we have critically evaluated EMR usage at the institution and have explored methods to improve the efficiency of our EMR documentation practices. Trauma represents one area of clinical care in which we have devoted substantial resources to the improvement of documentation practices. This focus was based on the importance of effective communication between providers and accurate documentation of treatment in trauma cases, which often requires rapid clinical decisions that are typically made by multiple subspecialists. Supracondylar humeral fractures, one of the most common fracture types requiring surgery in children, were selected as an area of strategic focus.

Supracondylar humeral fractures typically are associated with a benign clinical course. The prevalence of neurovascular deficits is low (2.6% to 4.6%)[5,6], but, if not detected early and addressed appropriately, these injuries can have considerable lifelong consequences[7]. Documentation of comprehensive vascular, motor, and sensory assessments is paramount to guiding treatment and improving patient care and safety. Because of the importance of early detection and appropriate management, we reviewed the preoperative documentation practices at our institution for all patients undergoing operative treatment of supracondylar humeral fractures. That preliminary study revealed that the comprehensive documentation of preoperative neurovascular status as assessed with vascular (8%), motor (56%), and sensory (49%) examinations was alarmingly less frequent than anticipated. To address this deficiency, a multidisciplinary team of clinical stakeholders was created to design and implement a set of standardized note templates to be embedded in the EMR. The purpose of the present study was twofold: (1) to describe the process by which a standardized note template was created in our institution's EMR, and (2) to compare the neurovascular screening documentation practices before and after the implementation of that standardized template.

## Materials and Methods

### *Historical Control Group: Pre-Template Group*

We conducted an initial review of patients who underwent operative treatment of a supracondylar humeral fracture between August 2009 and August 2010 (n = 515). Only those who had completely displaced fractures were considered for inclusion in the study. Patients who had a supracondylar refracture, open fracture, or intra-articular fracture as well as those who aspirated during surgery were excluded from the study (Fig. 1). Data related to demographic characteristics,

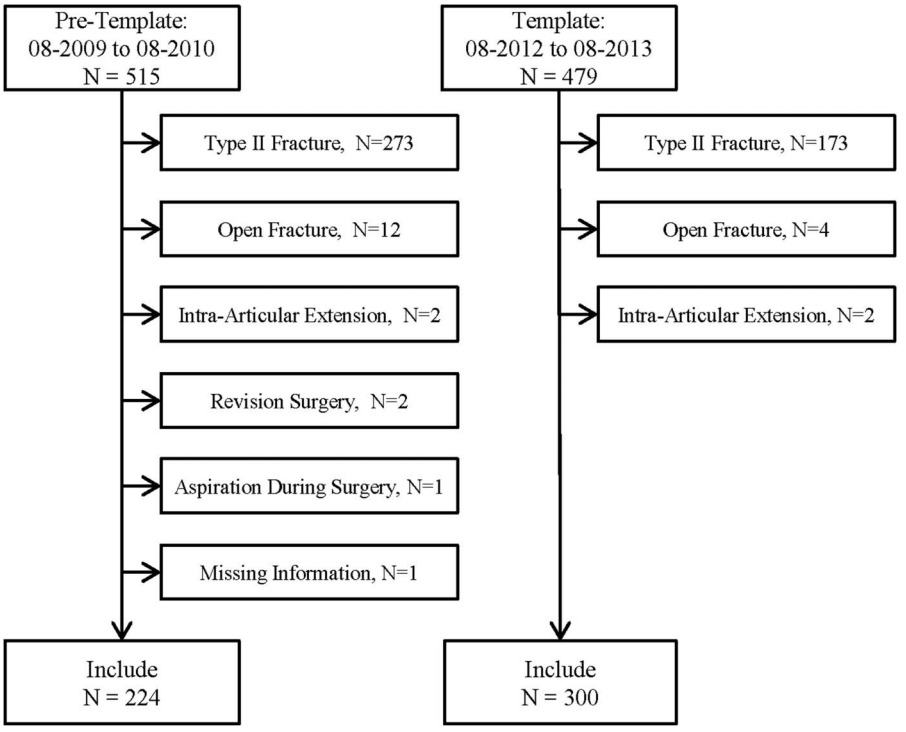


Fig. 1

Chart detailing patient enrollment. Patients were excluded from the pre-template (top left) and template (top right) groups for the reasons indicated in the boxes to the right of each vertical line. The number of patients included in each group is noted in the 2 boxes at the bottom of the chart.

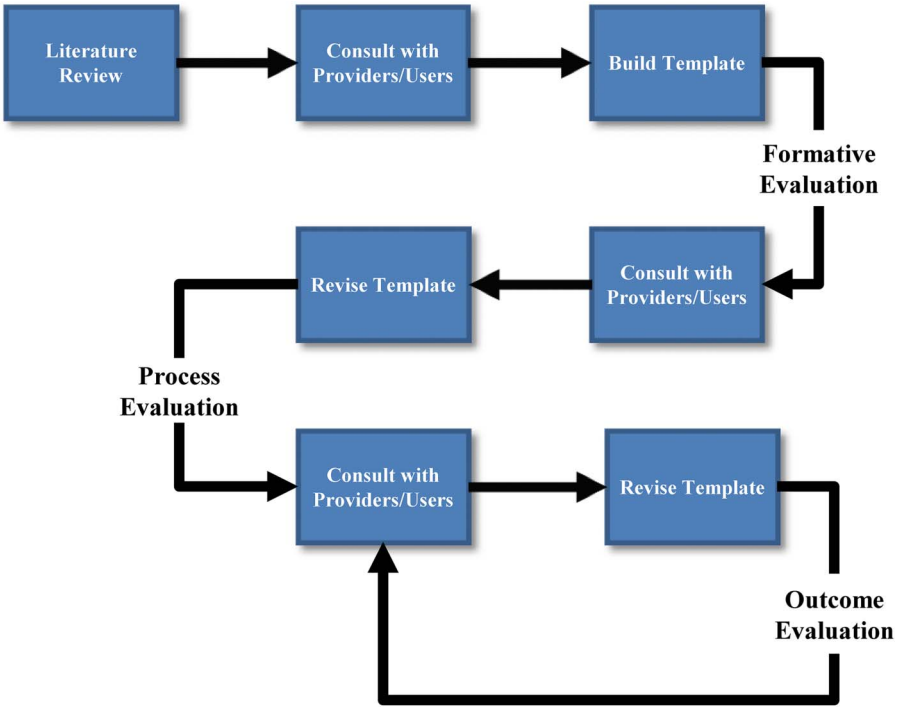


Fig. 2

Flowchart outlining the iterative methodology used to develop, implement, and refine the standardized note templates. The creation and implementation of the standardized template at our institution was a long and detailed process that took almost 2 years to complete, from 2011 to 2013. This process included standard note development (June 2011 to August 2012), formative evaluation (June 2011 to August 2012), and process evaluation (June 2012 to July 2012). The final step of template implementation at our institution was an ongoing outcomes/improvement process (August 2012 to August 2013), which involved the template group described in the present study.

clinical characteristics, surgical complications, and preoperative physical examination documentation (vascular, motor, sensory, and overall) were extracted. The proportion of charts that included a complete vascular, motor, sensory, and overall examination was analyzed. A complete preoperative vascular examination was defined as documentation of color, capillary refill, temperature, and radial pulse. A complete preoperative motor examination included notes on the motor function of the radial/posterior interosseous nerve, median/anterior interosseous nerve, and ulnar nerves. A complete preoperative sensory examination included notes on radial, median, and ulnar nerve sensory distributions. A complete overall examination included complete vascular, motor, and sensory examinations. The data collected in that preliminary study of 224 patients (the pre-template group) were used as an historical reference to represent documentation practices prior to the implementation of the standardized note template.

The charts of patients with vascular and nerve deficits were further evaluated to identify the time at which the neurovascular injuries were documented. An asymmetrical radial pulse on palpation at the time of presentation was used to define a vascular deficit. A sensory nerve deficit was defined as decreased or absent light-touch sensation in the respective peripheral nerve distributions, whereas a motor nerve deficit was defined as decreased or absent motor function in a myotome on examination.

*Template Development*

A multidisciplinary quality task force comprising 2 attending orthopaedic physicians, 1 attending orthopaedic upper-extremity surgeon, 1 physician assistant, 1 research assistant, and 1 representative from the bioinformatics department was formed. The goal of the group was to develop and implement a stand-alone, standardized note template that would improve neurovascular documentation practices for supracondylar humeral fracture. The components of the note template were initially developed on the basis of expert clinical input provided to the focus group as well as a review of the current literature (Fig. 2). We elected to avoid mandatory fields, giving providers a free-text field to document examination findings determined not to fit within one of the predefined categories (see Appendix).

A total of 6 templates were created and embedded into the EMR: (1) a preoperative consultation template for observations made on admission and/or immediately preoperatively; (2) a progress template for situations in which the child was not immediately taken to the operating room (also referred to as a rounding note); (3) an operative template for notes regarding intraoperative observations; (4) a postoperative template for notes on examination in the recovery room before discharge (postoperative progress note) and/or during the in-house postoperative stay (rounding progress note); (5) a postoperative template for notes made during clinical examination

**TABLE I Demographic and Clinical Characteristics**

| | Pre-Template Group (N = 224)* | Template Group (N = 300)* | P Value |
|---|---|---|---|
| Male | 111 (49.6%) | 140 (46.7%) | 0.5128 |
| Additional fracture | 13 (5.8%) | 12 (4.0%) | 0.3380 |
| Open reduction | 2 (0.9%) | 7 (2.3%) | 0.3126† |
| Nerve injury | 38 (17.0%) | 47 (15.7%) | 0.6902 |
| Vascular deficit | 10 (4.5%) | 18 (6.0%) | 0.4394 |
| Nerve injury and vascular deficit | 8 (3.6%) | 12 (4.0%) | 0.8000 |
| Provider | | | 0.6222 |
| Resident/fellow | 187 (83.5%) | 239 (79.7%) | |
| Attending | 16 (7.1%) | 28 (9.3%) | |
| Midlevel provider‡ | 21 (9.4%) | 29 (9.7%) | |
| Provider type missing | 0 (0.0%) | 4 (1.3%) | |
| Age§ *(yr)* | 6.2 ± 2.5 | 6.2 ± 2.3 | 0.7803 |
| Follow-up# *(wk)* | 6.1 (5 to 10) | 7.4 (5 to 10) | 0.1756 |

*The values are given as the number and percentage of patients unless otherwise indicated. †Fisher exact test. ‡Includes physician assistants and nurse practitioners. §The values are given as the mean and the standard deviation. #The values are given as the median and the interquartile range.

of the patient while the limb was immobilized in a cast; and (6) a postoperative template for notes made during clinical examination of the patient after removal of the cast. The present study analyzed the first of these templates (i.e., the preoperative consultation note template).

### *Formative Evaluation*

Once the templates were approved by the faculty, the bioinformatics representative aided in the incorporation of the notes into EPIC (EPIC Systems). The notes initially were implemented in June 2012. Additional modifications were made to the templates during a 3-month optimization period. The note templates were considered functional as of August 2012.

### *Process Evaluation*

User satisfaction with the note templates was assessed on the basis of qualitative interviews. Minor changes were made to the organization and appearance of the note templates. To assess compliance, a random sample of 50 patients was selected from a cohort of 261 patients who were treated after the initial implementation of the template (from May 2012 to October 2012). The rate of template compliance was 82% in this random subset of patients.

### *Outcome/Impact Evaluation: Template Group*

A query of ICD-9 (International Classification of Diseases, Ninth Revision) procedure and diagnostic codes was used to identify 479 fractures that were treated operatively between August 2012 and August 2013. A total of 300 patients met the criteria for inclusion in the template group (Fig. 1). Data related to demographic characteristics, clinical characteristics, and documentation of preoperative examinations (vascular, motor, and sensory) were extracted. The same definition of complete vascular, motor, sensory, and overall examinations that had been used for the preliminary study (pre-template group) was used for the template group. Patients with vascular and nerve deficits were evaluated to identify when the neurovascular injuries were first documented (i.e., preoperatively versus postoperatively).

### *Statistical Analysis*

Descriptive statistics were used to summarize the demographic and clinical characteristics of all patients. Chi-square, Fisher exact, or Student t tests were used to compare the demographic and clinical characteristics of the pre-template and template groups. Logistic regression analysis was used to compare the odds of complete vascular, sensory,

**TABLE II Crude Estimates of Complete Neurovascular Examination Documentation***

| | Pre-Template Group (N = 224) | Template Group (N = 300) |
|---|---|---|
| Complete vascular | 18 (8.0%) | 258 (86.0%) |
| Complete motor | 126 (56.3%) | 287 (95.7%) |
| Complete sensory | 110 (49.1%) | 287 (95.7%) |
| Complete examination | 8 (3.6%) | 255 (85.0%) |

*The values are given as the number and percentage of patients.

**TABLE III Description of All Nerve Injuries and Vascular Deficits***

| | Pre-Template Group (N = 224) | Template Group (N = 300) |
|---|---|---|
| Nerve injuries | | |
| Anterior interosseous nerve | 25 (11.2%) | 36 (12.0%) |
| Posterior interosseous nerve | 4 (1.8%) | 2 (0.7%) |
| Median only† | 3 (1.3%) | 0 (0.0%) |
| Radial only‡ | 5 (2.2%) | 8 (2.7%) |
| Ulnar only | 4 (1.8%) | 2 (0.7%) |
| Vascular deficits | | |
| Not palpable/Doppler only | 10 (4.5%) | 17 (5.7%) |
| Absent per Doppler ultrasound | 0 (0.0%) | 1 (0.3%) |

*The values are given as the number and percentage of patients.
†Excludes patients with an anterior interosseous nerve injury.
‡Excludes patients with a radial/posterior interosseous nerve injury.

motor, and overall examinations between the 2 groups. Examination completeness was based on all notes that were made prior to surgery. For patients in whom a nerve injury and/or vascular deficit developed, separate logistic regression analyses were used to compare the odds of the injury being identified in the pre-template and template groups prior to surgery. Age was included in all models as a potential confounding variable.

## Results

The pre-template group included 224 patients, and the template group included 300 patients. The demographic and clinical characteristics of the 2 groups were not significantly different with respect to age, sex, the presence of a concomitant fracture, the need for open reduction, nerve injury, nerve deficits, vascular deficits, provider type, or the duration of follow-up (Table I).

The proportions of preoperative notes with documentation of complete vascular, motor, sensory, and overall examinations were significantly ($p<0.0001$) greater in the template group than in the pre-template group (proportion of complete overall examinations, 85.0% [255 of 300] compared with 3.6% [8 of 224], respectively) (Table II). The odds of a complete vascular examination (odds ratio [OR], 70.7; 95% confidence interval [CI], 39.5 to 126.6; $p < 0.0001$), motor examination (OR, 17.6; 95% CI, 9.5 to 32.7; $p < 0.0001$), sensory examination (OR, 23.9; 95% CI, 12.9 to 44.4; $p < 0.0001$), and overall examination (OR, 153.9; 95% CI, 70.9 to 334.0; $p < 0.0001$) being conducted were significantly higher in the template group than in the pre-template group.

The prevalences of nerve injuries and vascular deficits were similar in the 2 groups (Table III). Among patients with a nerve injury, the timing of nerve-injury identification was significantly different between the groups. Nerve injuries were more likely to be identified prior to surgery in the template group (83.0%) than in the pre-template group (49.1%) (OR, 6.8; 95% CI, 1.7 to 27.1; $p = 0.0067$). There was no significant difference in the proportion of vascular deficits identified before surgery in the template group (72%) compared with the pre-template group (70%) (OR, 1.2; 95% CI, 0.2 to 7.0; $p = 0.8127$).

## Discussion

Early identification and treatment of neurovascular injuries associated with supracondylar humeral fractures is highly dependent on complete and consistent physical examinations. To our knowledge, this is the first study in the orthopaedic literature to evaluate standardized note templates embedded in the EMR in order to improve documentation. The implementation of the templates in the EMR was an active process, including time for optimization and adaptation, which was designed to improve treatment practices and clinical interventions. In the present study, the methodology for the implementation of standardized note templates resulted in a substantial improvement to the proportion of EMR notes with documentation of complete vascular, motor, and sensory examinations.

Numerous barriers to the implementation of a successful EMR system have been described[8]. Concerns exist regarding the completeness, accuracy, and quality of the available documented data[9], especially when free-text narrative notes are used to document objective findings. Therefore, some investigators have supported alternative methods, such as semi-structured notes with narrative text organized under standardized headings[3]. Fielstein et al. demonstrated that examination note templates utilized in the Veterans Affairs EMR were 10% to 26% more detailed and accurate than provider-dictated notes[2]. Semi-structured templates also have been reported to be favored by the physicians who read them as they can improve accuracy, organization, and completeness of the data collected while also aiding in clinical research by providing set locations for the data being utilized[3].

The growing dissatisfaction and disconnect between clinicians, hospital administrators, and information technology professionals regarding EMR systems represents another important barrier[4]. Most notably, many clinicians are dissatisfied with the lack of flexibility within the EMR system and the failure of institutions to engage clinicians during EMR implementation and/or adaptation[4]. The present report describes a reproducible method for minimizing these concerns. Structured template notes were developed on the basis of collaborative efforts between the bioinformatics department and clinical staff. By engaging the orthopaedic surgical faculty during the template development and implementation phases, we ensured that providers were invested in the process and that the templates appropriately reflected their clinical needs.

Implementation was an iterative process in which templates were introduced, tested, and subsequently modified until the end users were satisfied with their completeness and usability. The results of the intervention were extremely positive: the proportion of complete neurovascular examinations as documented in the EMR for patients with supracondylar humeral fractures jumped from 3.6% to 85.0%.

Improved documentation practices also contributed to earlier detection of neurological injuries associated with displaced supracondylar humeral fractures. In the case of an evolving neurological injury, an accurate and reproducible examination can assist in determining the proper timing of definitive surgical treatment. There is currently no definitive consensus with regard to the timing of operative fixation of displaced supracondylar humeral fractures with associated neurological injuries. However, early intervention should be considered as neurological injuries and severe elbow swelling can be early warning signs of compartment syndrome[7].

There are several additional benefits of earlier identification and documentation of a neurological deficit. First, in many hospitals, patient hand-offs can be frequent and can involve many different providers; therefore, having more complete and accurate notes can improve communication between multiple providers caring for the same patient. Second, parents of injured children may have a high level of anxiety, which can be exacerbated by inconsistent examination findings that may change already-established treatment plans. Finally, it is extremely important to identify and distinguish a preoperative neurological injury from an iatrogenic injury as the outcomes can be different and the medicolegal ramifications of a missed neurovascular injury can be prohibitive.

The use of standardized note templates at our facility did not contribute to earlier identification of vascular injuries in pediatric patients with displaced supracondylar humeral fractures. As vascular examinations are more objective than neurological examinations, and the latter might be harder to perform (especially in young children), the providers in the present study may have been more likely to identify vascular injuries than neurological injuries both before and after the introduction of the templates.

The present study had several limitations. Data from the pre-template group were collected on the basis of a retrospective chart review. Neurovascular examination documentation data were limited to preoperative notes only. We observed no difference in the prevalence of nerve injuries between the pre-template and template groups. It is possible that the note templates improved documentation practices but had no meaningful impact on the identification of nerve and vascular injuries. However, as the true prevalence of nerve injuries in the 2 groups was not known, the examination accuracy could not be assessed within the 2 groups. Another limitation is that we did not directly measure improvements in patient outcomes, although earlier documentation of neurological injuries was used as a surrogate marker for improved clinical outcomes under the assumption that early documentation has the potential to lead to improved patient outcomes. However, additional research is needed to determine whether early documentation is associated with a decreased risk of adverse outcomes. Additionally, we were unable to determine the true prevalence of nerve and/or vascular injuries. Estimates of injury prevalence are limited by the accuracy of measurements based on physical examinations. Finally, improvements in documentation practices were only evaluated during a 1-year period. It is unclear whether improvements in documentation practices will be retained when the study team is not actively measuring provider compliance. Future studies should assess whether template usage results in more efficient delivery of medical care, earlier identification of potentially preventable complications associated with other injuries, improvement in patient safety, or higher-quality data for research purposes.

The results of the present study indicate that standardized templates embedded within the EMR can improve the clinical documentation of pediatric supracondylar humeral fractures. A multidisciplinary team approach, including both providers and bioinformatics personnel, was essential to the formation, implementation, and clinical optimization of the templates; this methodology could easily be utilized to improve clinical documentation in other orthopaedic diagnoses. Although the technical details of template implementation are likely to vary across commercial EMR systems, we believe that our methodology of engaging clinicians during EMR development and implementation is likely to be successful regardless of the EMR platform.

## Appendix

eA A figure showing a sample note template is available with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJSOA/A22). ■

Jue Cao, MD[1]
Ryan Farmer, MD[1]
Patrick M. Carry, MS[2]
Maria Goodfellow, BA[2]
David C. Gerhardt, MD[1]
Frank Scott, MD[1]
Travis Heare, MD[1]
Nancy H. Miller, MD[1,2]

[1]Department of Orthopedics, University of Colorado Denver, Denver, Colorado

[2]Musculoskeletal Research Center (P.M.C., M.G., and N.H.M.) and Department of Orthopaedics (P.M.C. and N.H.M.), Children's Hospital Colorado, Aurora, Colorado

E-mail address for N.H. Miller: Nancy.Miller@childrenscolorado.org

ORCID iD for N.H. Miller: 0000-0002-8107-3943

## References

**1.** Wright A, Sittig DF, McGowan J, Ash JS, Weed LL. Bringing science to medicine: an interview with Larry Weed, inventor of the problem-oriented medical record. J Am Med Inform Assoc. 2014 Nov-Dec;21(6):964-8. Epub 2014 May 28.

**2.** Fielstein EM, Brown SH, McBrine CS, Clark TK, Hardenbrook SP, Speroff T. The effect of standardized, computer-guided templates on quality of VA disability exams. AMIA Annu Symp Proc. 2006:249-53.

**3.** Johnson SB, Bakken S, Dine D, Hyun S, Mendonça E, Morrison F, Bright T, Van Vleck T, Wrenn J, Stetson P. An electronic health record based on structured narrative. J Am Med Inform Assoc. 2008 Jan-Feb;15(1):54-64. Epub 2007 Oct 18.

**4.** Shaha JS, El-Othmani MM, Saleh JK, Bozic KJ, Wright J, Tokish JM, Shaha SH, Saleh KJ. The growing gap in electronic medical record satisfaction between clinicians and information technology professionals: issues of most concern and suggested remediations. J Bone Joint Surg Am. 2015 Dec 02;97(23):1979-84.

**5.** Choi PD, Melikian R, Skaggs DL. Risk factors for vascular repair and compartment syndrome in the pulseless supracondylar humerus fracture in children. J Pediatr Orthop. 2010 Jan-Feb;30(1):50-6.

**6.** Sabharwal S, Tredwell SJ, Beauchamp RD, Mackenzie WG, Jakubec DM, Cairns R, LeBlanc JG. Management of pulseless pink hand in pediatric supracondylar fractures of humerus. J Pediatr Orthop. 1997 May-Jun;17(3):303-10.

**7.** Ramachandran M, Skaggs DL, Crawford HA, Eastwood DM, Lalonde FD, Vitale MG, Do TT, Kay RM. Delaying treatment of supracondylar fractures in children: has the pendulum swung too far? J Bone Joint Surg Br. 2008 Sep;90(9):1228-33.

**8.** Kruse CS, Kristof C, Jones B, Mitchell E, Martinez A. Barriers to electronic health record adoption: a systematic literature review. J Med Syst. 2016 Dec;40(12):252-. Epub 2016 Oct 6.

**9.** Richesson RL, Hammond WE, Nahm M, Wixted D, Simon GE, Robinson JG, Bauck AE, Cifelli D, Smerek MM, Dickerson J, Laws RL, Madigan RA, Rusincovitch SA, Kluchar C, Califf RM. Electronic health records based phenotyping in next-generation clinical trials: a perspective from the NIH Health Care Systems Collaboratory. J Am Med Inform Assoc. 2013 Dec;20(e2):e226-31. Epub 2013 Aug 16.