Rapid deployment of an algorithm to triage dental emergencies during COVID-19 pandemic

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ABSTRACT

COVID-19 quickly immobilized healthcare systems in the United States during the early stages of the outbreak. While much of the ensuing response focused on supporting the medical infrastructure, Columbia University College of Dental Medicine pursued a solution to triage and safely treat patients with dental emergencies amid the pandemic. Considering rapidly changing guidelines from governing bodies, dental infection control protocols, and our clinical faculty’s expertise, we modeled, built, and implemented a screening algorithm, which provides decision support as well as insight into COVID-19 status and clinical comorbidities, within a newly integrated electronic health record (EHR). Once operationalized, we analyzed the data and outcomes of its utilization and found that it had effectively guided providers in triaging patient needs in a standardized methodology. This article describes the algorithm’s rapid development to assist faculty providers in identifying patients with the most urgent needs, thus prioritizing treatment of dental emergencies during the pandemic.

Key words: screening algorithm, telehealth, COVID-19, dental emergencies, electronic health records

INTRODUCTION

At a media briefing on March 11, 2020, the director-general of the World Health Organization (WHO) characterized the novel coronavirus (COVID-19) as being responsible for a worldwide pandemic.1 This virus, transmitted mainly by respiratory droplets, is known as severe acute respiratory distress syndrome (SARS-CoV-2).1,2 It leads to infection, which may vary in patients from being asymptomatic to pneumonia—and sometimes results in death.1 As of January 31, 2021, there have been worldwide over 102 million documented cases resulting in 2.2 million deaths, of which an estimated 26 million cases and 440,094 deaths have occurred in the United States.3 On March 20, 2020 the mayor of New York City declared the city the epicenter of the pandemic with 5151 cases and 29 deaths at the time.4

The College of Dental Medicine (CDM) at Columbia University, located in New York City, has approximately 120,000 patient visits annually. It serves as the primary dental provider to a significant portion of the surrounding metropolitan area, a large population of which is underserved. 170 students, 83 postgraduate students (PG), and 40 hospital dental residents (HD) (all under the supervision of dental faculty) provide direct patient care in the dental clinics. A CDM COVID-19 task force suspended all elective procedures after considering a multitude of factors, including the city’s high population density, its reliance on public transportation, and the virulence of COVID-19 infection. The CDM emergency dental clinics remained open, continuing to serve the community and reducing the need for patients to seek urgent dental care at already overburdened emergency rooms. Initially, PG students were allowed to provide treatment, but shortly after, 50 faculty from specialties including General, Oral Surgery, Pediatrics, Endodontics, and Orthodontics and 9 HD residents treated emergency patients. The providers screened patients for COVID-19 symptoms; if the patient was symptomatic, febrile, or had recent exposure to someone with COVID-19, nonurgent care was deferred. Learning that many of the walk-in emergency patients indeed fit the criteria to postpone treatment or manage medically, CDM rapidly deployed a telehealth strategy,
piloting a clinical decision support (CDS) algorithm for 4 weeks, ultimately deploying at full scale.

The use of telehealth visits, conducted by dental faculty, quickly became essential in allowing patients to be triaged to appropriate care while at the same time limiting potential viral exposure for patients, providers, and ancillary staff. The fact that there were no documented incidents of viral transmission among faculty, staff, or residents is evidence of the strategy’s effectiveness. Furthermore, following recommendations from The Center for Medicare and Medicaid Services (CMS), these actions preserved personal protective equipment (PPE), ensuring its availability for patients with emergent needs.

It became increasingly difficult for providers to keep up with rapidly developing guidelines for treating patients with suspected or confirmed COVID-19 and to define which dental emergencies to manage medically via telehealth. The decision to treat a patient in the dental clinic has an added layer of complexity due to the generation of droplets and aerosols during dental procedures. Aerosol-generating procedures (AGPs) increase the risk of transmission of the virus between patient and provider. In response to these challenges, CDM developed a decision support algorithm which was embedded into a newly deployed, enterprise-wide, joint medical and dental (EHR) system, EPIC. This algorithm provides evidence-based best practices based on Center for Disease Control and Prevention (CDC), American Dental Association (ADA), and CDC infection control policies for safely treating patients with dental emergencies during this pandemic. It analyzes variables that one should consider when screening patients before treatment in the dental clinic, including the nature of the patient’s dental problem, COVID-19 status, and comorbidities. Decision support generates customized recommendations ranging from delaying treatment, to referral to the cough and fever clinic, to treatment with full PPE, including N95 masks and negative pressure rooms.

**OBJECTIVE**

This pilot’s goal was to maximize visits to the dental clinic for patients requiring emergent care. CDM sought to do this by developing a CDS tool that guided faculty screeners to evaluate patients with dental emergencies objectively and consistently.

**MATERIALS AND METHODS**

The design of the algorithm is to stratify risk in order to identify patients who are likely to have a poor outcome if care is delayed, as well as reduce patients with nonemergent needs seeking care in the emergency rooms, preventing overuse of dental emergency services. CDM developed Acuity Levels (Table 1) with corresponding recommendations as the output of the algorithm based on a decision tree (Figure 1).

![Figure 1](image1.png)

The Acuity Levels are based on a patient history of pain, swelling, bleeding, trauma, and comorbidities and are critical to delineating treatment. To best establish an accurate Acuity Level as related to pain, the need for more descriptive terminology describing the pain experience and impact on quality of life rather than a numeric value was identified and incorporated in the algorithm. A variety of factors, including age, sex, ethnic background, sleep status, and previous experiences may contribute to individual assessments of pain. What may be a pain level of 9 for one individual may be a 4 for another person or for that same person in different settings.

**Table 1. Acuity levels**

| Acuity Level | Recommendations              |
|-------------|-------------------------------|
| Level I     | No intervention required      |
| Level II    | Non urgent, recommend comprehensive care |
| Level III   | Palliative care               |
|             | • Patient instructions        |
|             | and/or                        |
|             | • Pharmacologic intervention  |
| Level IV    | Referral to dental clinic     |
| Level V     | Refer to emergency room       |

Since this is a subjective measurement, we determined that an objective and reproducible measure should be derived to establish the patient’s pain assessment score. As such, the faculty screener asks the patient a series of objective questions (Figure 2), some leading to cascading items, from which the algorithm calculates a pain assessment score of None, Moderate, or Severe. This pain assessment score is a crucial factor in determining a final Acuity Level and providing guidance for treatment recommendations. Of the patients that reported pain, 80% indicated that it impacted their daily activities.

Additionally, objective questions regarding trauma, bleeding, and swelling are included in the algorithm’s calculation. One must consider how comorbidities may potentially influence the patient’s clinical outcome. Specific comorbidities may elevate the Acuity Level when combined with conditions such as swelling or pain (without relief by medication). Although comorbidities are self-reported at this time, the EHR’s patient problem list is readily viewable, which may prompt further discussion. The comorbidities we considered included diabetes, patients undergoing chemotherapy or radiation, transplant patients, artificial cardiac valve, and immunocompromised patients.

Depending on the results of the dental screening algorithmic calculation, a new series of questions for COVID-19 symptoms will be presented. A final recommendation considering both the dental screening and COVID-19 status guides the provider to the appropriate recommendations (Figure 3).

Although this paper’s focus is on telehealth prescreening, dental faculty perform screenings in the emergency dental clinic, whether the patients are walk-ins or referred based on telehealth encounters. The goal of the in-person screenings is to quickly determine the patient’s COVID-19 status using the algorithm questions, allowing the faculty screener to immediately move a patient with potential COVID-19 to an isolation room where the dental screening is completed (Figure 3A). Evaluating the faculty screener’s assessment and treatment recommendations, the algorithm calculates additional levels of precautions based on the need for treatment that may include AGPs (Figure 3B).

In this pilot, the clinician used the algorithm; however, it was designed to enable nonclinicians to run the algorithm to determine acuity level, thus freeing up provider resources.

In order to implement the algorithm, we utilized calculation functions within clinical documentation flowsheets and developed a decision tree to guide the providers through the complex process of determining the appropriate treatment pathway while adhering to the CDC, ADA, and CDM guidelines.

Each flowsheet row prompted the user to input choices, and the formulas in the background dynamically calculate interim results, which are used for further computations downstream. The algo-
Figure 1. Decision tree.

Pain Screen
Are you having oral or facial pain?
Yes
No

Are you taking any medications to relieve pain?
Yes
No

If applicable, what kind of medications?
Acetaminophen
Ibuprofen
Naproxen (i.e. Aleve)
Aspirin
Prescription pain medications

Is pain causing problems with eating or sleeping?
Yes
No

Describe the pain
Sharp
Dull
Throbbing

Has the quality of pain changed?
Yes
No

Pain assessment

Pain assessment interpretation
Moderate

Figure 2. Pain screening.
The algorithm was implemented as a combination of switch statements, in which each of the pertinent flowsheet rows (FSR) is evaluated with conditional statements to determine the final result. For example, a subset of pain-related FSRs have the following associated numeric values:

- $$f_{\text{Pain}}$$: No = 0; Yes = 1
- $$f_{\text{Meds Relief}}$$: No Meds = 0; Pain relief with Meds = 1; No Pain Relief with Meds = 2

When the user inputs the answers to these prompts, this piece of code— $$(f_{\text{Pain}} = 0 : 0, (f_{\text{Meds Relief}} = 2 : 2, (f_{\text{Meds Relief}} = 1) ! (f_{\text{Pain}} = 1): 1, 1, 0)$$—will produce a pain score. This translates to:

- If Pain is No, then set score to 0, which corresponds to no pain
- If (Pain is Yes OR Pain Relief with Meds is Yes), then set score to 1, which corresponds to moderate pain
- If (No Pain relief with Meds is Yes), then set score to 2, which corresponds to severe pain

Similarly, Acuity Level permits the following FSR choices:

- $$f_{\text{Bleeding}}$$: None = 0; Controlled = 1; Uncontrolled = 2
- $$f_{\text{Trauma}}$$: None = 0; Dental = 1; Facial = 2; Dental + Facial = 3
- $$f_{\text{Swelling}}$$: None = 0; Oral = 1; Facial = 2; Oral + Facial = 3
- $$f_{\text{Medical Clearance}}$$: None = 0; Clearance for Medical Procedure = 1; Dental Biopsy = 2; Suture Removal = 3
- $$f_{\text{Comorbidities}}$$: None = 0; Diabetes = 1; Chemotherapy = 2; Radiation = 3; Transplant = 4; Cardiac Valve = 5; Immunocompromised = 6

Taking these into consideration, Acuity Level IV would be satisfied with this criteria: $$(|\text{Pain Score}| > 2) ! (|\text{Bleeding}| > 2) ! (|\text{Swelling}| > 1) ! (|\text{Medical Clearance}| > 0) ! (|\text{Trauma}| = 1) ! (|\text{Swelling}| = 1) ! (|\text{Comorbidities}| > 0): 4]$$, which translates to:

- If (No Pain Relief with Meds)
- OR (Uncontrolled Bleeding)
- OR (Facial Swelling)
- OR (Needs a Medical Clearance, Biopsy, Suture Removal)
- OR (Dental Trauma AND Oral Swelling)
- OR (Oral Swelling AND Any Comorbidity)
- Then set Acuity Level to IV

### RESULTS

After implementing this new algorithm, we tracked utilization and assessed the results from the screening to determine if it was achieving its goals. Data were analyzed to determine whether the algorithm was successfully delineating patients that could postpone treatment, be managed medically, or needed to visit the clinic for an in-person evaluation.

Over the course of our pilot, algorithm utilization increased during the first 4 weeks, averaging 83 per week. From 3/23/2020 to 6/4/2020 a total of 1274 telehealth screenings were performed on 1108 patients (Table 2).

Due to organizational policies, the emergency clinic was operating at a reduced capacity with limited resources (providers, operators, PPE, and negative pressure rooms). To ensure that we were able to treat the patients with the greatest need, CDM developed a standardized method to prioritize the needs of emergent patients over those that may be treated medically or remotely. The algorithm ultimately provided the solution, enabling consistent evaluation.
across all providers, standardizing acuity levels, and allowing schedulers and triage personnel to prioritize urgent needs.

The overall rate of follow-up visit to the dental emergency clinic post screening was 30% with or without algorithmic usage. However, when utilizing the algorithm, the rates of patients that did need emergency care based on Acuity Level was 63%.

DISCUSSION

One of the primary goals of building this clinical decision tool was to optimize the usage of limited resources during the COVID-19 pandemic—in this case, access to emergency care dental services. By creating the screening tool and algorithm based on recommendations from the ADA, CDC, and CDM infection control policies, we were able to shift the mix of patients that were seen for emergency care. This result shows that the use of this screening tool did meet its goals of optimizing which patients were seen in the emergency dental clinic as opposed to patients that did not require urgent care and could be managed medically or deferred until the clinics reopened for routine care.

CONCLUSION

As we enter the new normal that is a result of COVID-19, we must rethink the dental care delivery model. By virtue of the patient’s age and comorbid risk factors, coronavirus exposure potentially places one at high risk for serious illness and possible death. Healthcare delivery, in general, will look very different based on the need to maintain social distancing, reduce crowding in reception areas, and manage the physical spacing requirements to prevent transmission of the virus.

In a short time, CDM was able to develop a screening algorithm that limited patients, providers, and staff exposure to the virus, while at the same time identifying patients in need of emergent care and facilitating the delivery of that care. Utilization of this screening algorithm is an efficient and productive means to evaluate potential dental and oral health emergencies and may be beneficial to consider as a model for screening dental emergencies in the future.

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AUTHOR CONTRIBUTIONS

All authors made substantial contributions to the development and design of this project, as well as the writing of the manuscript and interpretation of the data.

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DATA AVAILABILITY

Data available on request.

CONFLICT OF INTEREST STATEMENT

None declared.

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