BMJ Health & Care Informatics

Telehealth dashboard: leverage reporting functionality to increase awareness of high-acuity emergency department patients across an enterprise practice

Heather A Heaton ,[1] Christopher S Russi,[1] Ryan J Monroe,[2] Kristine M Thompson,[3] Karen A Koch[4]

To cite: Heaton HA, Russi CS, Monroe RJ, *et al*. Telehealth dashboard: leverage reporting functionality to increase awareness of high-acuity emergency department patients across an enterprise practice. *BMJ Health Care Inform* 2019;**26**:e100093. doi:10.1136/bmjhci-2019-100093

Received 03 September 2019
Revised 08 November 2019
Accepted 03 December 2019

Check for updates

[1]Department of Emergency Medicine, Mayo Clinic, Rochester, Minnesota, USA
[2]Bluetree Network, Madison, Wisconsin, USA
[3]Department of Emergency Medicine, Mayo Clinic, Jacksonville, Florida, USA
[4]Department of Nursing Informatics, Mayo Clinic, Rochester, Minnesota, USA

Correspondence to
Dr Heather A Heaton; heaton.heather@mayo.edu

ABSTRACT

Background Emergency Medicine Telehealth (TeleEM) represents an opportunity to work directly with referral centres, rural facilities and underserved areas to mitigate unnecessary testing, optimise resource utilisation and facilitate patient transfers across health systems. To optimise the impact of a TeleEM programme, a tool is needed to remotely monitor patient activity in multiple emergency department facilities, concurrently.

Methods After identifying data sources for activation criteria put forth by the TeleEM operations group, rules were constructed within the electronic health record to facilitate data checks and ultimately produce a yes/no response if the category's conditions were met. Responses were organised into a table, with functionality allowing end users to drill into the different sites to see patient-specific information for patients meeting activation criteria.

Conclusions The TeleEM dashboard allows for proactive engagement by the TeleEM physician and strengthens the team-based approach of critically ill.

BACKGROUND

The USA has seen a dramatic expansion in telehealth programme driven by the critical need to provide high-quality care while reducing healthcare costs.[1–24] To date, most acute care telehealth activity has focused on Telestroke[1 2]; however, Emergency Medicine (EM) is a specialty uniquely positioned to directly impact patient movement and system utilisation. Approximately 40% of clinicians practising EM are not board-certified. The proportion of a board-certified to non-board-certified EM clinicians favours urban settings when compared with rural areas.[25] Emergency Medicine Telehealth (TeleEM) represents an opportunity to work directly with referral centres, rural facilities and underserved areas to optimise resource utilisation and facilitate patient transfers across health systems.

To fill this need, our institution developed a TeleEM programme serving 18 regional hospitals. Initially, criteria were created and distributed encouraging providers in these facilities to contact the TeleEM physician when they were in need of video or phone consultation. The engagement was limited as often the time when they needed the most help coincided with an interval when making a phone call was impractical. An opportunity was discovered: the TeleEM providers needed a mechanism to be able to identify which sites were caring for patients who were critically ill or providers who may be in need of assistance due to high census or mass casualty across a large, primarily rural, geographically dispersed healthcare system.

OBJECTIVE

The TeleEM Dashboard was created to provide TeleEM physicians with a means to remotely monitor patient activity in multiple emergency department (ED) facilities, concurrently, within a single frame of view. We describe the development of a novel dashboard to create system-wide situational awareness and provide opportunities for earlier intervention by a TeleEM team.

METHODS

The display is driven by a single query, identifying active ED visits by selecting encounters with an ED arrival date/time and a null ED departure date/time within the electronic health record (EHR) application database. The query is re-submitted approximately every 5 min using a batch scheduling process as the principal data refresh mechanism.

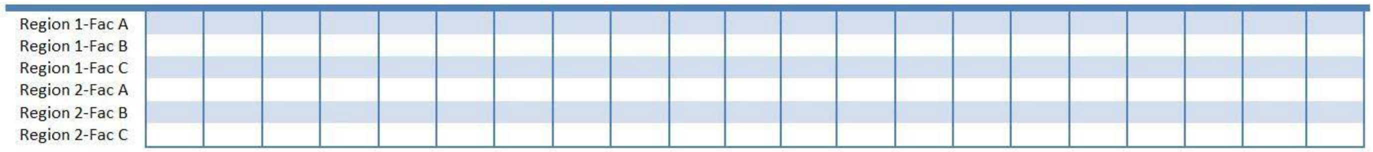

Figure 1 TeleEM Dashboard matrix display format.

Query output volumes for the enterprise typically range between 200 and 300 concurrent visits during midday and evening hours, decreasing to 50–100 visits in the overnight period.

The output is organised in a matrix display format, reserving a row for each ED facility. The facility's geographical region is concatenated with its name as the top-level grouping in a single-tier hierarchical structure. This method was chosen to consolidate data for presentation while still allowing the user to visually aggregate data by region through a dual sorting technique (figure 1).

After establishing a base query and data presentation structure, we considered how to balance our goal of pre-emptive patient identification based on our telehealth programme's activation criteria, with limited data afforded by near real-time monitoring. For example, if a local clinician suspects that a patient may have an intracranial haemorrhage, data present within the EHR provide few options for early identification of this situation by a remote audience. A diagnostic finding, such as the result of a head CT, could provide a reliable data source; however, the examination's turnaround time precludes its use as an early identification mechanism.

Alternatively, the clinician may articulate a hunch and related decision-making in a working draft of the visit. Although we thought that this could potentially mitigate data availability issues at times, data storage within our EHR presented a limitation. As of the date of this publication, medical decision-making within ED provider notes was not stored discretely and we did not have integration with a natural language processing tool that could facilitate a technical path forward. As a result, we considered other more readily available data sources as potential markers:

- ESI (Emergency Severity Index) level: patient's acuity as assessed on presentation.
- Chief complaint: patient's principal complaint(s) as recorded on patient arrival.
- Vital signs: initial and subsequent measurements manually recorded or automatically captured in the EHR through biomedical device integration.
- Ventilator usage: indication based on device data such as flow rate or ventilator mode of operation manually recorded or automatically captured in the EHR through biomedical device integration.
- Medical history: discrete medical history data of diagnosed conditions or problems from across the continuum of care.
- Active care plans: discrete, condition and patient-specific care from across the continuum of care.
- Clinical decision support: existing asynchronous alerts built into our EHR, which continually assess biometric data and diagnostic findings to aid in the identification of certain high-risk conditions.
- Documentation tool use: metadata maintained in our EHR that identifies the use of scenario-specific charting tools for trauma, code, sedation, stroke and potential ST-elevation myocardial infarction (STEMI) cases.
- Order set selection: metadata maintained in our EHR which identifies the use of complaint or scenario-oriented order sets.
- Medication ordering behaviour: groupers of orderable medications categorised by pharmacological indications.

These data sources became the basis for a cross-walk, mapping TeleEM activation criteria into broader alert categories that could leverage available data markers as illustrated in table 1.

With this initial set of alert categories defined, we devised a rule-based approach to evaluate each active visit returned in the master query against a set of rules (21) that would independently test each alert category's conditions. These rules contained a mixture of functions using standard logical operations to perform direct data checks as well as additional embedded sub-level rules as demanded by the category's level of evaluation complexity, particularly if multiple data types were to be examined (eg, vitals data plus chief complaint…or medical history plus use of a specific order set).

Ultimately, each top-tier level rule produced a Boolean response, where 1-Yes signified affirmation that an alert category's conditions were met. We then assigned a column to each alert category on the matrix display and used a 'total count' function to sum the number of 1-Yes responses found for each region-facility combination present in the row data. To improve readability, a colour-coding schema was applied to produce a red highlight whenever a row's count of 1-Yes responses was greater than 0 (figure 2). Based on this preemptive warning, remote viewers could drill down into the underlying visit details for each facility and ultimately the respective patient chart to further assess the situation prior to contacting the local clinician.

LIMITATIONS

In the course of developing the TeleEM dashboard, we were confronted with technical, human and contextual challenges that imposed limitations on the tool's utility.

Table 1 TeleEM activation criteria mapping to alert categories

Activation criteria	ALERT category	Data source
Critical care	ESI 1	ESI level
Critical care	ESI 2	ESI level
Level yellow or red trauma resuscitations	Trauma	Documentation tool usage
Cardiac arrests or haemodynamic instability/shock	Code	Documentation tool usage
Intracranial haemorrhage	Stroke	Documentation tool usage
Chest pain—including STEMI and NSTEMI	STEMI	Documentation tool usage
Need for sedation—agitation or procedural	Sedation	Documentation tool usage
Sepsis or suspected sepsis	Sepsis	Clinical decision support
Suspected shock	Shock	Clinical decision support
Neutropenic fever or fever in immunocompromised host	Neutropenia	Clinical decision support
Unresponsive mental status	Unresponsive	Chief complaint
Haemophilia with possible acute bleeds	Haemophilia	Medical history, active care plans
Moderate or severe croup	Croup	Chief complaint
Significant burns, neonatal fever, suspected child abuse	Other CC	Chief complaint, vitals
Various	Antibiotics	Medication ordering behaviour
Symptomatic atrial fibrillation	Antiarrhythmic/antihypertensive	Medication ordering behaviour
Haemorrhage with current anticoagulation status	Anticoagulant	Medication ordering behaviour
Adverse drug events, anaphylaxis, bronchiolitis	Epinephrine/allergic reaction treatment	Medication ordering behaviour
Diabetic ketoacidosis	Insulin	Medication ordering behaviour
Respiratory failure or distress	Respiratory treatment	Medication ordering behaviour, ventilator usage
Toxic ingestions, overdose or exposure	Reversal agents/overdose treatment	Medication ordering behaviour

CC, chief complaint; ESI, Emergency Severity Index; NSTEMI, non-ST-elevation myocardial infarction; STEMI, ST-elevation myocardial infarction.

Technical

At the time of this publication, our commercial EHR did not provide a means to assess alert categories for multiple patient records, concurrently, *in real time*. Functionality existed, pursuant to a user trigger, for real-time evaluation of all criteria within an individual patient record; conversely, in order to facilitate a multiple record evaluation, we were limited to using a queue, recurring system process or a scheduled batch process. The smallest interval we could reasonably allow a job or process to recur was 5 min in order to avoid negative performance issues. This concern precluded providing users with a means to perform an ad-hoc display refresh.

Human

We acknowledge that an alert system partially premised on metadata acquired through system use itself is susceptible to error, both false positives and complete misses. When

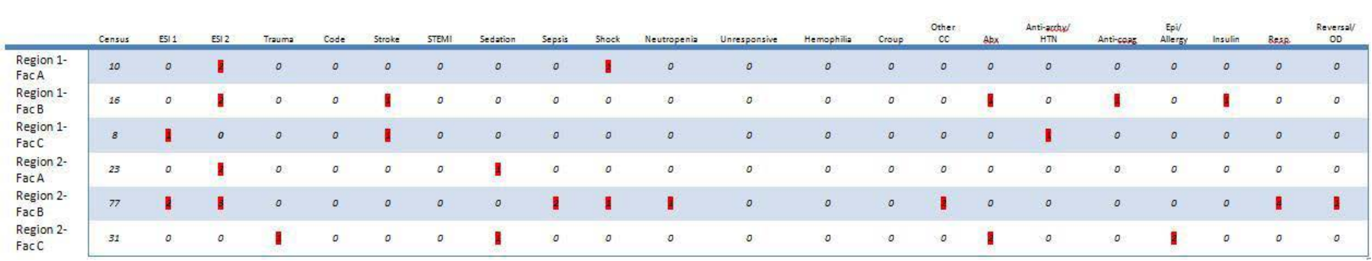

Figure 2 TeleEM Dashboard alert category display by facility.

implementing our EHR, best practice system workflow was determined and provided the basis for the training curriculum as well as this tool's design. However, as the system continues to evolve, new users join the user base and existing users seek more efficient ways to document in the EHR, it is unrealistic to assume that prescribed system use workflows are followed in every case.

Contextual

The contextual limitations stemmed from a lack of discrete data availability. At the time of this publication, our organisation captured most provider documentation in a note feature that stored a mixture of structured and unstructured data points. Certain elements such as the patient's history of present illness, physical examination findings and a review of systems were generally available as discrete data points within a provider note; however, other key data like medical decision making and course/workup comments were not harvestable without the use of an integrated natural language processing application. As a result, we had to consider alternative data points from the available pool to drive our category alert mechanisms which, at times, made them overly broad. We see the addition of a natural language processing platform as the next logical path to refine our alert sensitivity by targeting decision-making input directly, as opposed to relying on secondary sources.

Finally, a lack of precise data contributed to the difficulty in crafting alerts for a subset of activation criteria due to the risk of over-alerting. This is particularly problematic for criteria that may align with a high volume of visits, yet, have additional parameters applying only to a subset, or are generally areas where TeleEM providers are only consulted by request. For example, remote providers may offer assistance to local clinicians treating patients for severe headaches or migraines, yet to produce an alert for every patient presenting with an arrival complaint of headache or migraine may lead to alert fatigue or desensitisation. Comparable challenges existed for other activation criteria such as difficult epistaxis, abdominal pain of unclear aetiology and active seizures. Again, we see opportunities with natural language processing tools to advance alerting capabilities in these areas.

DISCUSSION

Despite the technical, human and contextual challenges faced by the build team, utilisation of the EM TeleEM Dashboard has created an opportunity to enhance value for each patient encounter. Traditional TeleEM provides a video or phone consultation only when activated by the receiving provider. The development of the EM TeleEM Dashboard allows for *proactive* engagement by the TeleEM physician. In our practice, the dashboard has allowed for quick identification of critically ill patients across our sites and increased the use of the collaborative approach telemedicine provides.

Although TeleEM physicians cannot demand utilisation, they can encourage its use especially for resource-limited and geographically dispersed EDs. Ten of our EDs hold a federal critical access (CA) designation. Those low-volume, rural EDs are often staffed with a nurse practitioner (NP), physician assistant (PA) and one or two nurses (RN). Critically ill patients demand a team-based approach, and the addition of the TeleEM physician, via video, can offload the cognitive burden of the rural provider by providing clinical guidance and arranging ambulance or helicopter transport, allowing them to focus on the patient at the bedside. Furthermore, the dashboard allows the teleEM physician the opportunity to identify situations where initiating telemedicine could benefit the patient and the healthcare team, removing the onus of making initial contact in stressful situations for already stretched care teams.

CONCLUSIONS

TeleEM has significant potential to increase the quality of care and decrease resource utilisation in EDs across the country. Engagement with the service can be significantly enhanced through the development of a TeleEM Dashboard promoting the proactive engagement of the TeleEM physician.

Contributors HAH, CSR, RJM, KMT and KAK: involved with study concept and design. HAH, RJM and KAK: participated in acquisition of the data. HAH, CSR, RJM and KAK: participated in analysis and interpretation of the data; all were involved in the initial draft of the manuscript; all participated in critical revision of the manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

ORCID iD

Heather A Heaton http://orcid.org/0000-0001-6683-1315

REFERENCES

1 Ambroise B, Benateau H, Garmi R, *et al*. The role of telemedicine in the management of maxillofacial trauma in emergency departments - preliminary results. *J Stomatol Oral Maxillofac Surg* 2019;120:95–8.
2 Barnett ML, Ray KN, Souza J, *et al*. Trends in telemedicine use in a large commercially insured population, 2005-2017. *JAMA* 2018;320:2147–9.
3 Brennan JA, Kealy JA, Gerardi LH, *et al*. A randomized controlled trial of telemedicine in an emergency department. *J Telemed Telecare* 1998;4:18–20.
4 Brennan JA, Kealy JA, Gerardi LH, *et al*. Telemedicine in the emergency department: a randomized controlled trial. *J Telemed Telecare* 1999;5:18–22.
5 Chi CH, Chang I, Wu WP. Emergency department-based telemedicine. *Am J Emerg Med* 1999;17:408–11.

6 Gillespie SM, Shah MN, Wasserman EB, *et al*. Reducing emergency department utilization through engagement in telemedicine by senior living communities. *Telemed J E Health* 2016;22:489–96.
7 Greenwald PW, Stern M, Clark S, *et al*. A novel emergency Department-Based telemedicine program: how do older patients fare? *Telemed J E Health* 2019;25:966–72.
8 Hicks LL, Boles KE, Hudson ST, *et al*. Using telemedicine to avoid transfer of rural emergency department patients. *J Rural Health* 2001;17:220–8.
9 Izzo JA, Watson J, Bhat R, *et al*. Diagnostic accuracy of a rapid telemedicine encounter in the emergency department. *Am J Emerg Med* 2018;36:2061–3.
10 Keane MG. A review of the role of telemedicine in the accident and emergency department. *J Telemed Telecare* 2009;15:132–4.
11 Kelton DK, Szulewski A, Howes D. Real-Time video telemedicine applications in the emergency department: a scoping review of literature. *CJEM* 2018;20:920–8.
12 Machado SM, Wilson EH, Elliott JO, *et al*. Impact of a telemedicine eICU CART on sepsis management in a community hospital emergency department. *J Telemed Telecare* 2018;24:202–8.
13 Mohr NM, Harland KK, Chrischilles EA, *et al*. Emergency department telemedicine is used for more severely injured rural trauma patients, but does not decrease transfer: a cohort study. *Acad Emerg Med* 2017;24:177–85.
14 Mohr NM, Vakkalanka JP, Harland KK, *et al*. Telemedicine use decreases rural emergency department length of stay for transferred North Dakota trauma patients. *Telemed J E Health* 2018;24:194–202.
15 Mohr NM, Young T, Harland KK, *et al*. Emergency department telemedicine shortens rural Time-To-Provider and emergency department transfer times. *Telemedicine and e-Health* 2018;24:582–93.
16 Paik AM, Granick MS, Scott S. Plastic surgery telehealth consultation expedites emergency department treatment. *J Telemed Telecare* 2017;23:321–7.
17 Stamford P, Bickford T, Hsiao H, *et al*. The significance of telemedicine in a rural emergency department. *IEEE Eng Med Biol Mag* 1999;18:45–52.
18 Tachakra S, Banitsas KA, Tachakra F. Performance of a wireless telemedicine system in a hospital accident and emergency department. *J Telemed Telecare* 2006;12:298–302.
19 Tolia V, Castillo E, Guss D. EDTITRATE (emergency department telemedicine initiative to rapidly accommodate in times of emergency). *J Telemed Telecare* 2017;23:484–8.
20 Weymouth W, Thaut L, Olson N. Point of view telemedicine at point of care. *Cureus* 2018;10:e3662.
21 Woods LW, Snow SW. The impact of telehealth monitoring on acute care hospitalization rates and emergency department visit rates for patients using home health skilled nursing care. *Home Healthc Nurse* 2013;31:39–45.
22 Zachrison KS, Boggs KM, M Hayden E, *et al*. A national survey of telemedicine use by US emergency departments. *J Telemed Telecare* 2018. doi:10.1177/1357633X18816112. [Epub ahead of print: 17 Dec 2018].
23 Bowman DL. Case studies demonstrating stroke telemedicine in the rural emergency department. *J Emerg Nurs* 2017;43:70–1.
24 Geisler F, Kunz A, Winter B, *et al*. Telemedicine in prehospital acute stroke care. *J Am Heart Assoc* 2019;8:e011729.
25 Hall MK, Burns K, Carius M, *et al*. State of the National emergency department workforce: who provides care where? *Ann Emerg Med* 2018;72:302–7.