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AEM Education and Training

CONCEPT

Resident clinical dashboards to support precision education in emergency medicine

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Abstract

Introduction: With the move toward competency-based medical education (CBME), data from the electronic health record (EHR) for informed self-improvement may be valuable as a part of programmatic assessment. Personalized dashboards are one way to view these clinical data. The purpose of this concept paper is to summarize the current state of clinical dashboards as they can be utilized by emergency medicine (EM) residency programs.

Methods: The author group consisted of EM physicians from multiple institutions with medical education and informatics backgrounds and was identified by querying faculty presenting on resident clinical dashboards at the 2024 Society for Academic Emergency Medicine conference. Additional authors were identified by members of the initial group. Best practice literature was referenced; if none was available, group consensus was used.

Categories of Metrics: Clinical exposures as well as efficiency, quality, documentation, and diversity metrics may be included in a resident dashboard. Resident dashboard metrics should focus on resident-sensitive measures rather than those primarily affected by attendings or systems-based factors.

Considerations for Implementation: Implementation of these dashboards requires the technical expertise to turn EHR data into actionable data, a process called EHR phenotyping. The dashboard can be housed directly in the EHR or on a separate platform. Dashboard developers should consider how their implementation plan will affect how often dashboard data will be refreshed and how to best display the data for ease of understanding.

Implications for Education & Training: Dashboards can provide objective data to residents, residency leadership and clinical competency committees as they identify areas of strength, growth areas, and set specific and actionable goals. The success of

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resident dashboards is reliant on resident buy-in and creating a culture of psychological safety through thoughtful implementation, coaching, and regular feedback.
Conclusion: Personalized clinical dashboards can play a crucial role in programmatic assessment within CBME, helping EM residents focus their efforts as they advance and refine their skills during training.

INTRODUCTION

The Accreditation Council for Graduate Medical Education (ACGME) requires that residents "must receive data on quality metrics and benchmarks related to their patient populations."[1] Despite the move toward competency-based medical education (CBME) in graduate medical education (GME), most trainees do not currently reliably receive the clinical data necessary to understand their learner progression and engage in informed self- and programmatic assessment. Precision education (PE) has been introduced as a conceptual framework to promote value-based, equitable care within the CBME approach and can serve as a valuable part of programmatic assessment. PE operates in "cycles" that use data inputs such as educational activities, electronic medical records, and patient care outcomes to generate insights that drive precision interventions on the individual learner level, such as just-in-time educational programming and coaching.[2] Ongoing adjustment is made for repeated cycles of improvement.

Personalized dashboards, defined as a visual display of data useful for decision making, are one modality by which clinicians can view their performance data.[3] Patient care and quality dashboards incorporating such metrics for practicing physicians have proliferated over the past 15 years, with evidence suggesting that they improve both adherence to quality guidelines and patient outcomes.[4,5] Other specialties have piloted and integrated clinical performance metrics (CPMs) into dashboards for trainees; these include automated case logs for patient volume and diagnosis in pediatric training[6,7] and case-based quality metrics in anesthesia.[8,9] There remains, however, a dearth of literature on dashboard use among emergency medicine (EM) training programs.[10]

The purpose of this concept paper is to review the landscape of clinical dashboards for EM residency training programs within the conceptual framework of CBME. We aim to cultivate a fuller understanding of the current state of metric reporting, considerations made prior to a program's implementation of a resident clinical dashboard, and future directions of trainee performance data feedback within the greater contexts of EM GME.

METHODS

The author group was composed of individuals known to the first and senior author (JM and BS) to be presenting on electronic health record (EHR) clinical dashboards for learner education at the 2024 Society for Academic Emergency Medicine (SAEM) conference in Phoenix, Arizona, suggesting a high level of content area expertise (Table 1). Recognizing the need for interdisciplinary collaboration, this concept paper comprises leaders in emergency medical education, clinical and educational informatics, and data analytics. To identify potentially missed individuals and ensure comprehensiveness, the SAEM annual meeting app was searched with the keyword "dashboard" and each result was reviewed. Additional authors with relevant expertise were identified by allowing each member of the initial group to suggest an additional faculty member with relevant expertise from their institution for inclusion in the author group, similar to snowball sampling.

Writing took place from June 2024 to September 2024. While individual authors crafted each section, the entire article was reviewed by all authors for content, and edits and revisions were made based on feedback from all authors. Collaborative writing took place over Google Docs (Alphabet) asynchronously. Where available, best practice literature was referenced; if none was available, group consensus was used.

Categories of metrics

Clinical exposure metrics

Resident assessments have included elements related to clinical exposure for at least a century.[11] Recognizing that learning in GME is largely experiential, clinician-educators have sought to quantify trainees' clinical experience using evolving technologies, from manual tally sheets that categorized clinical presentations seen by family practice residents in the 1970s[12] to logs on a departmental PC of EM residents' diagnoses, resuscitations, and procedures at the turn of the century.[13,14]

However, manual entry relying on trainees is fraught with challenges, including timeliness of submission, accuracy, and burden on the individual.[15–17] Researchers have demonstrated that reliance on individual logging is underrepresentative of procedures performed compared to actual procedures completed as documented in the EHR.[18] Leveraging EHR documentation has offered education leaders more accurate sources of procedural capture to better address deficits in procedural exposure for trainees.[18]

In addition to procedural exposure, subsequent studies have described other aspects of the clinical experience of residents, including the frequency and types of diagnoses encountered to quantify primary care resident experiences with various conditions.[19,20] Such data have been applied to creating experiential

TABLE 1 Author training and roles related to clinical dashboards.

Author name	Training	Role	Years of experience
Joe-Ann S. Moser, MD, MS	GME Education Scholarship Fellowship (2023–2024)	Assistant Residency Program Director	1
Nicholas Genes, MD, PhD, FACEP	ABPM certification in clinical informatics	Fellowship Director, Clinical Informatics Fellowship	3
	Certification in Epic Physician Builder Analytics	Physician Informaticist	12
Daniel J. Hekman, MS	Master's Degree in Population Health	Data Scientist	6
	Multiple Epic certifications		
Sara M. Krzyzaniak, MD		Residency Program Director	5
Timothy A. Layng, DO	ACGME Clinical Informatics Fellowship (2019–2020)	Director of Informatics, Department of Emergency Medicine	5
	ABPM certification in Clinical Informatics, Epic Physician Builder, and Physician Builder Analytics certifications	Director of Medical Scribe Program	
	Epic Emergency Medicine Specialty Steering Board Member		
Danielle Miller, MD, MEd	Medical Education Scholarship Fellowship (2019–2021) Fundamentals of Electronic Health Record Data Research, Center of Innovative Design and Analysis, Anschutz Medical Campus (2021)	Director of Individualized Education Committee	2
Ashley C. Rider, MD, MEHP	Simulation Education Fellowship (2019–2021)	Associate Program Director	3
	Master of Education in the Health Professions, Research Track (2019–2021)		
Selin T. Sagalowsky, MD, MPH	Masters of Public Health (health education program measure and evaluation focus, 2007)	Vice Chair for Education, Department of Emergency Medicine	11
	AAMC Medical Education Research Certificate (MERC) Program (2018)	Faculty Member, Precision and Translational Medical Education Laboratory, Institute for Innovations in Medical Education (IIME)	
		Formerly: Fellowship Director (Pediatric Emergency Medicine); Director of Medical Student Education	
Moira E. Smith, MD, MPH	ACGME Clinical Informatics Fellowship (2022–2024)	Assistant Emergency Medicine Informatics Director	2
	Epic Physician Builder and Physician Builder Analytics certifications	Director of Digital Clinical Workflows	
Benjamin H. Schnapp, MD, MEd	Medical Education Scholarship Fellowship (2015–2016)	Director of Residency Evaluation and Assessment	8
	Master of Education with a Focus on Health Professions (2015–2018)	Graduate Medical Education Fellowship Director	

Abbreviations: AAMC, Association of American Medical Colleges; ABPM, American Board of Preventive Medicine; ACGME, Accreditation Council for Graduate Emergency Medicine; GME, graduate medical education.

dashboards for trainees and program leadership to track clinical experience in real time.[6,21] Most recently, colleagues in internal medicine designed a crosswalk tool that maps resident clinical experiences to the American Board of Internal Medicine's certification exam clinical domains, thereby leveraging the EHR to create an educationally meaningful taxonomy.[22,23] Using personalized and programmatic dashboards, these data were applied to understand variability in trainee experiential learning, tailor learning to the individual, and inform programmatic curriculum design, with an analogous model covering chief complaints encountered currently being piloted by study authors (NG, DH, STS, BS) within the field of EM.

In addition to quantifying exposure to procedures and chief complaints, EM residents may benefit from tracking of patient acuity to ensure adequate exposure to critical illness during their training. This could be identified in various ways in the EHR, including Emergency Severity Index (ESI) level; critical care billing codes; trauma, stroke, or sepsis activations; or use of vasoactive medications. Residents identified as having lower exposure in this area could receive interventions such as targeted simulations or

preferential scheduling to ensure they gain competency in treating the sickest patients.

Efficiency metrics

Among many skill sets, a feature of top clinical performance in EM is a trainee's clinical efficiency.[24] The Model of Clinical Practice of Emergency Medicine created by the American Board of Emergency Medicine (ABEM) includes "task switching/multiple patient care" to capture this patient care competency.[25,26] A comprehensive measure of patient flow captures activity over several shifts or even months of shifts, which can be presented in dashboard form. EHR data offers a new, improved layer of data on efficiency practices that may be less subject to the unique circumstances of a given shift.

In adherence to the outcomes-focused training of CBME, trainees must have experience with flow metrics that are a component of EM practice. A scoping review on productivity measures for EM physicians showed that the most frequently reported metrics are patients per hour (PPH), provider-to-disposition time, and relative value units (RVUs).[27] In regard to resident productivity specifically, PPH and patient ED length of stay have been described in the literature.[28–31] The RVU is commonly used for reimbursement, determining staffing needs, and judging productivity.[32] Previous literature demonstrated that RVUs also have a pattern of progression as a function of year in residency.[33–35] Given the importance of RVUs as a metric to evaluate independent practitioners in EM and the ability to track progression reliably, this metric is useful as a data point in the overall assessment of patient flow.

Efficiency metrics included in a resident dashboard should focus on factors within a resident's locus of control rather than systems-based factors. For example, a door-to-doctor time metric includes components out of a resident's control, such as a patient's waiting room time. Instead, using a metric such as room-to-doctor time hones in on a more resident-specific activity (efficiently seeing patients) and can allow an opportunity for residents to see improvements in individual performance with a direct impact on the metric over time. However, the relevance of individual metrics may vary by site; it is unlikely that a standardized set of metrics, much less benchmarks for those metrics, could be relevant in all training environments. For example, some sites may find value in a "time to first order" metric for residents to assess efficient decision-making workflows, while sites with a physician-at-triage model may find no assessment value in that data set due to the confounder of the triage physician's initial orders. Based on this literature and implementation across the specialty of EM, clinical dashboards for residents should contain productivity metrics, such as RVU calculations or PPH, that account for acuity and time spent performing procedures and physician-to-disposition time.

However, acknowledgment of factors that may not be squarely in the domain of residents to control is vital in their understanding of their role in a larger healthcare system. It is also important to place EHR data in the context of what residents should expect from future employers and normalize that performance assessment, however imperfect, is a part of a career in clinical EM.

Quality metrics

Quality indicators are another domain that may be beneficial to report to residents on a dashboard. Dashboard-facilitated personalized feedback with peer comparison to EM clinicians has proven effective for improving a variety of quality measures, including reducing opioid prescribing, imaging utilization, admission, and revisit rate.[36–39] However, quality metrics for residents may be among the most fraught with confounding. As residents in the emergency department (ED) always have an attending available to staff with and who is usually closely overseeing or even directing their work, identifying quality metrics that are attributable primarily to the actions of the resident (so-called "resident-sensitive quality measures" or RSQMs) can be difficult to identify.[40,41] For example, a resident may have ordered a large percentage of CT scans on their own or by having this course dictated to them by the attending they are working with; a dashboard is unable to discriminate between these two possibilities that likely have very different implications for how to coach the resident on their future practice. Timely performance of sepsis quality measures has been considered an appropriate RSQM, since residents may identify sepsis and order sepsis bundle elements before discussion with an attending is feasible[31]; one study of resident trainees showed improved compliance with sepsis resuscitation bundles after education and personalized feedback.[38]

Documentation metrics

Documentation and billing is another layer of an EM physician's productivity; residents overall have been shown to have limited knowledge of documentation standards.[42,43] Feedback on billing codes, which can be easily provided in dashboard format, can be an important source of education beyond didactics of standard billing and coding practices. Previous research has shown that simple educational interventions can increase the evaluation and management chart levels billed by residents.[33] Additionally, at sites where documentation is completed after shift, time from encounter to note signature is an easily tracked measure that can improve compliance with hospital documentation expectations and may improve patient care.[44] Additional documentation metrics that could be considered include documentation length and use of dictation to evaluate whether these variables may be affecting timely resident chart completion.

Diversity metrics

Clinical exposure to patients from various social identities may be another important construct for EHR clinical dashboards to measure,

as physician biases against patients of other racial, ethnic, socioeconomic, and ability statuses are well documented in the literature, and direct contact and social interaction with members of these groups has been shown to reduce these biases.[45] While racial and ethnic backgrounds can be difficult to define, research has shown that the reliability of these data in the EHR seems to be relatively high, with less than 2% of recorded data for adults discordant with previous visits,[46] although incomplete data in this area are currently an issue. Skillful use of an interpreter is a best-practice communication method,[47] but one that requires significant experience to perfect; resident exposure to patients requiring interpreter services could be easily tracked and displayed. Other indirect markers, such as insurance status, may serve as useful and accessible EHR proxies of important patient characteristics like socioeconomic status.

However, there are a variety of patient social identities that are currently less amenable to resident dashboards. Gender identity and sexual orientation are currently not well documented in the EHR; despite having been recommended as a best practice, implementation has been poor, although plans are in progress for improvement.[48] Additionally, patients' ability status and religious beliefs are not systematically collected or stored unless relevant to patient care (e.g., Jehovah's Witnesses and blood transfusions). These may represent areas for improvement for future iterations of resident dashboards as EHR data collection continues to improve.

Considerations for implementation

Resident-sensitive metrics

While the field of EM widely utilizes CPMs as described above, such traditional metrics have been criticized for failing to represent the clinical work performed by trainees due to the supervisory and team-based dynamics of academic EDs.[40] RSQMs, defined as clinical care measures that are both important to providing care for an illness of interest and likely completed by a resident (rather than another member of the team or by the team collectively), have been developed in pediatric emergency and internal medicine, demonstrating a wide range of performance characteristics.[41,49–51] While RSQMs may address skepticism associated with poor individual attribution, they suffer from a lack of timeliness for effective feedback and difficult scalability across programs.[20]

Not all traditional CPMs are applicable at a specific training level, and RSQMs may hinder delivery of timely feedback and can be difficult to scale across programs. Recent research within EM has introduced the concept of a new type of measure, TRainee Attributable & Automatable Care Evaluations in Real-time (TRACERs), which are meant to be meaningful, attributable to trainees, automatable, scalable, and real time.[20] A concerted effort to identify such a national system of high-density, trainee-attributable, patient-centered outcome measures would mean we would not have to rely solely on "plugging in" existing traditional CPMs and RSQMs into trainee dashboards. In the meantime, we can identify those existing CPMs and RSQMs that are most attributable to learners, have resident buy-in, align with organizational/programmatic goals, are transparent, reflect and report on recent data, and use clear and consistent goals for target performance.

EHR phenotyping

Taking the messy, real-world data contained in EHRs and turning it into actionable areas for improvement for residents requires defining specific disease constructs, resident tasks, and patient outcomes in terms of the EHR itself, a process sometimes called EHR phenotyping.[13] This is an inherently time-consuming and iterative process that requires collaboration between clinical experts, workflow experts, and technical experts. For example, the basic premise of any resident dashboard that includes patient outcome measurements assumes the ability to attribute a given patient's care to a resident. In an EHR database with many relationships between patient and provider dimensions over time, this seemingly simple task can be done in any number of ways. Attributing care to the first resident assigned to the care team, the resident assigned to the care team the longest, or the resident who wrote the first ED provider note are all reasonable choices for an algorithm, but all will have pros and cons in terms of ease of coding, erroneous data, data lag, and corner cases, so it is unlikely that any will be perfectly accurate for all patients visits. For example, a system that attributes care to the first assigned resident (who often performs the majority of the critical medical decision-making) would miss entirely the care provided by a resident who took that patient in signout and performed a complex resuscitation when the patient later decompensated. Similarly, an attribution system that preferences resident assigned the longest would be problematic when the first resident performed a majority of the history, physical exam, data review, plan creation, and consult calling in the last 30 minutes of their shift, but a resident receiving sign-out spends just a few moments with the patient while awaiting consultant recommendations and disposition for several hours.

Once developed, operationalizing an EHR phenotype in code and visualizing those metrics in a dashboard requires a specialized skill set with knowledge of multiple computer coding languages, data visualization tools, EHR data models, and secure server infrastructure to store and disseminate reports. While some EDs may employ a data scientist or physician informaticist to assist in optimizing operations and tracking quality metrics, these activities often leave little time to devote to developing and reporting educational metrics for residents. This lack of dedicated resources is exacerbated by the lack of uniformity in EHR systems; for example, how the initiation of a consultation or "code sepsis" gets documented and stored in the database can be different across hospital systems, even those using the same EHR vendor. There is also a lack of standards for many common quality measures, such as return visits,[14] and variables that impact resident performance, such as crowding.[19] Further adding to the confusion is the lack of current requirements for PE from the ACGME that could be used to create content for dashboards. While

this currently requires significant program- and institution-level effort, as more institutions develop and share resources, barriers to entry will likely come down for programs interested in creating their own dashboards.

Dashboard platform

Dashboards can either be housed directly within the EHR or on a separate platform.

Built-in dashboards

EHR dashboards are built on a report-based framework. When data can be captured and displayed in a specific field, those data can be added to a report, which is then incorporated into a dashboard component and ultimately shown on a dashboard amidst other components. EHR dashboards can be built by either the vendor (EHR company) or the customer (specific institution). These dashboards often facilitate direct linkage to patient charts based on patient attribution logic (e.g., first, last, or longest ED attending). For example, Epic's "ED Provider - My Metrics" dashboard, a vendor-built dashboard, is configured to display information for the longest ED Attending assigned to the treatment team, by default. This highlights the importance of data definitions such as patient attribution as a first step to implementing dashboards, as this definition may be inaccurate in many ED environments (e.g., those with prolonged boarding times). Furthermore, if the dashboard is to be used for multiple types of providers (attending physicians, resident physicians, advanced practice providers, etc.) then the dashboard, as well as the components, reports, and summaries that feed the dashboard, need to be duplicated and access permissions assigned accordingly.

The "ED Provider - My Metrics" dashboard has a number of built-in components that display information for a physician for the current and prior month. The throughput metrics component has generic ED throughput information such as number of patients, average acuity, median doc-to-dispo time, average billing level of service, and total length of stay. A note-signing efficiency component utilizes prebuilt logic to identify if a note was signed within the encounter, within a day of the encounter, within 3 days, and within 1 week of the encounter. If an organization's coding, billing, and revenue cycle workflows are also fully integrated into Epic, the professional level of service component displays information about the number of encounters broken down by the level of service billed for the encounter, including a designation for critical care encounters.

Dashboards external to the EHR

For dashboards housed on a separate platform, queries of clinical data are facilitated through EHR extracts, transformations, and loading into a data lake or data warehouse, referred to in shorthand as the extract–transform–load (ETL) process. The first step is the extraction of clinical data from the EHR; analytic software such as Tableau or PowerBI makes use of structured query language (SQL) to bring together disparate data tables, such as ED procedures performed by residents, ED notes written by residents, orders placed by residents, and patient diagnoses and dispositions and can also integrate sources beyond the EHR, such as resident schedules (to align data points for shift start and end times) and patient satisfaction scores. Extraction may be followed by the use of a statistical programming method such as SAS, R, or Python for transformation of the data. Finally, the data are loaded into a repository for viewing. For example, the analyst can run the data through an RMarkdown or Quarto template that generates individual HTML and word documents for each resident summarizing data points with figures.[52,53] This process requires a data analyst with, at minimum, statistical knowledge and experience with SQL, coding, and data visualization.

Comparing built-in and external dashboards

Dashboards built directly into the EHR have several advantages; they provide residents with continuous access to real-time, patient-linked data without having to wait for data distribution from their residency program leadership. Built-in EHR dashboards also offer convenience, especially for those institutions without access to clinical data repositories or data analysts with statistical knowledge and coding experience. External dashboards that rely on an ETL process require significantly more resources to develop, fine-tune, and distribute and would only be able to reflect updates at the frequency of the ETL. Furthermore, EHR dashboard users only need to view one platform instead of having to interface with multiple platforms, which reduces efficiency with an increased number of mouse clicks and an overall increased cognitive load inherent in switching between platforms.[54,55]

A disadvantage of the vendor-built EHR dashboards is they tend to show simpler, less-sophisticated measures; accounting for exclusion criteria and specific clinical conditions is best accomplished via SQL queries of data lakes. Attribution features in vendor-built dashboards are predetermined and may not align with institutional concepts of patient ownership. Another limitation is EHR dashboards can typically only pull data from the past 30 days, which generally only encompasses a single resident rotation and therefore limits the capture of longitudinal progression.

Data frequency

Data on a clinical dashboard can be displayed continuously or can be refreshed daily, weekly, monthly, or quarterly. Logistical and practical considerations both play a role in determining the ideal interval. Depending on which platform is used and how data are being obtained, it may be simple or highly challenging to achieve frequent updates on chosen metrics. Some dashboards require significant resources for data extraction and storage, and only extracting this data on a monthly or quarterly basis is the most efficient use of technological resources. On the other hand, a dashboard pulling straightforward metrics integrated into the EHR may be able to pull up-to-the-minute data on demand at any time. However, it is also important to consider how data are likely

to be utilized by both programs and learners. For some metrics, like PPH, that benefit primarily from a large number of measurements over time, frequent updating may be less critical, as longer sampling times allow for some degree of smoothing of individual patient and shift effects.

Data visualization

Many resources exist to outline general best practices for graphical presentations of data,[3,56–58] and a review of data visualization principles is beyond the scope of this paper. The foremost principle of data visualization is that the visualization should be readily understood by the target audience. Therefore, the authors recommend taking an iterative approach to dashboard visualization.[59] Teams should meet regularly to review the progress of dashboards, explain visualizations to residents, and make updates on a semiregular cadence based on feedback from key stakeholders, especially education faculty, chief residents, and junior residents seeing the dashboard for the first time. Updates will include refining data visualizations that residents (the target audience) find unclear or too complicated as well as adding additional metrics over time.

Implications for education and training

Dashboard use by residents, residency leadership, and clinical competency committee (CCC)

Once obtained, information from clinical dashboards can augment multiple facets of residency education. CCCs, charged with ensuring residents are progressing adequately throughout training, can use dashboard measurement areas to demonstrate resident achievement in various ACGME core competencies (Table 2). These objective data can confirm or challenge the group's consensus on resident performance. For example, if a resident is perceived as inefficient, a rising "patients per hour" metric for that resident might suggest that the group's perception is outdated; similar dashboards aggregating performance data have been successfully integrated into the CCC process.[60] This approach, utilizing objective performance data, may also be helpful for reducing known bias in the assessment process.[61] During semiannual meetings with residents, it can often be difficult for residents and faculty to identify and agree on areas for growth; one pilot study suggests that dashboard data was perceived as helpful by both residents and faculty for better identifying areas of relative strength and weakness.[62] Additionally, having objective numbers available on clinical dashboards can allow for measurable goal setting and accountability at subsequent semiannual meetings instead of goals that are often ill-defined. For example, "I'd like to get more comfortable with seeing sick patients" might become "I'd like to see 10% more ESI 1 patients than I saw over the last 6 months." Similarly, residents who are on remediation may benefit from the ability to track growth via dashboards in real time; a resident deficient in timely documentation, for example, would be able to demonstrate progress after only a few shifts. Additionally, these data may be valuable for residency-level program evaluation. For example, if all residents are noted to be seeing a low volume of cardiac patients, a new rotation in the cardiac ICU could be considered. If multiple residents are struggling with the same quality metric, educators can create a learning module or simulation to address the issue. Finally, even programs with a highly functional and usable dashboard implementation should consider frequent program evaluation with stakeholders to ensure that the dashboard continues to meet the needs of all parties Table 2 and 3.

TABLE 2 Example of mapping CPMs to ACGME competencies.

Measurement areas	ACGME competencies
Clinical exposure (acuity, diagnoses, procedures)	Patient care and procedural skills
Efficiency (RVUs, PPH)	Systems-based practice
Documentation	Systems-based practice
Quality metrics (compliance with sepsis measures)	Practice-based learning and improvement, medical knowledge
Equitable care (exposure to patients across social identities, interpreter use)	Professionalism, interpersonal communication skills

Abbreviations: ACGME, Accreditation Council for Graduate Emergency Medicine; CPMs, clinical performance metrics; PPH, patients per hour; RVUs, relative value units.

Resident buy-in and behavior modifications

The success of resident dashboards for improving performance is largely reliant upon resident buy-in, and educators must utilize a deliberate and thoughtful strategy in the introduction of EHR metric usage to residents. Educators should clearly communicate the process of how metrics were developed, selected, and attributed to convey the purpose of the dashboard as one of many tools in providing formative feedback to learners in the course of their training. While one qualitative study supports that residents generally embrace EHR data for feedback, assessment, and the development of clinical practice patterns,[63] in a different pilot of public metric dashboards for EM residents, trainees did not view them as reflective of their quality of care, and 16% felt "very" or "extremely pressured" to alter their practice patterns.[64] If the dashboard includes metrics that are perceived as less resident-sensitive, residents may appear hesitant to receive feedback, when in fact they may be disregarding the feedback as they feel it is outside their locus of control.

Therefore, psychological safety is an important concept to consider in dashboard use. Psychological safety refers to the state in which members of a team feel safe taking interpersonal risk and expressing themselves and has been adapted in GME to refer to trainees' comfort with receiving feedback and acknowledging deficits.[65,66] To our knowledge, there is currently no evidence-based research in improving psychological safety in resident physicians, and

TABLE 3 Resident clinical dashboards at authors' institutions.

Institution	Dashboard platform	Frequency of updating/length of data look back	Metric categories included
New York University Grossman School of Medicine	Epic EHR, Tableau	Daily, weekly, monthly (with multiyear lookback)	Clinical exposure, efficiency, quality, documentation
Stanford University	Google Drive, HTML/PDF	Quarterly	Clinical exposure, efficiency, quality
University of Colorado School of Medicine, Anschutz Medical Campus	Power BI	Daily	Clinical exposure, efficiency, quality
University of Virginia	Epic EHR	Daily	Clinical exposure, efficiency, documentation
University of Wisconsin, Madison	R/Quarto[52]	Quarterly	Clinical exposure, efficiency, quality, documentation, diversity

Abbreviations: EHR, electronic health record.

this will be an area requiring further research as dashboards become more widely utilized. Based on recommendations from the business world applied to the context of resident dashboards, educators can achieve psychological safety by setting clear expectations ahead of time that the dashboards will not be used punitively, instead using them collaboratively with a trusted coach in a confidential, formative, and low-stakes manner and contextualizing the metrics as only one piece of a broader picture of overall competence as a physician.[67] If coaches are comfortable sharing, offering up examples of their own struggles in some of the dashboard domains (e.g., timely chart completion) may help residents feel comfortable sharing their vulnerabilities.

A limitation in interpreting resident performance data is the lack of widely accepted performance standards across each year of training that prevent comparison across programs. This is in part due to the inherent variability in EM (e.g., the COVID-19 pandemic changed the variety of patients presenting to the ED) and partly due to significant heterogeneity across training sites and resident expectations for each training year. One way to mitigate this is to use peer comparison, ideally de-identified to support psychological safety. This approach controls for institution-specific nuances that could impact the residents' experiences and provides norm-referencing standards for assessment over periods of time. However, peer comparison data can be influenced by particularly high- or low-performing cohorts as well as changes in the clinical environment over time and must be utilized and interpreted with caution.

Educators should also be mindful of the potential for the Hawthorne effect to influence resident behavior; the Hawthorne effect is "an increase in the performance of individuals who are noticed, watched, and paid attention to by researchers or supervisors."[68] A careful selection of metrics for inclusion in a dashboard may mitigate this tendency. For example, including both room-to-doctor and doctor-to-dispo times makes it harder for a resident to positively influence the first metric without negatively influencing the second unless they can simultaneously improve their efficiency of dispositioning patients. Additionally, utilizing a wide range of metrics, rather than focusing on one or two, may help residents begin to view their performance holistically, rather than myopically focusing on a single area of their practice for improvement.

Finally, learners are known to dismiss feedback that is incongruent with their own self-assessment and worldview. This may impact their acceptance of performance metrics if they are given data to suggest, for example, that they are not seeing as many patients each shift as their peers, yet they consider themselves to be faster than the rest of their class. One important way to mitigate this is to utilize guided self-assessment using a coaching model,[69] where impartial coaches help learners make sense of external data and set realistic and verifiable goals. However, implementation of such a model requires a significant amount of upfront faculty training as well as longitudinal buy-in by both faculty and residents.

These experiences highlight the need for programs to engage meaningfully in the creation, implementation, and ongoing feedback of dashboards in a manner that ensures psychological safety and efficacy. Furthermore, programs should monitor trainee well-being, as data from outside the EM training context suggest peer comparison data may decrease job satisfaction and contribute to burnout.[70]

SUMMARY RECOMMENDATIONS

As residency training in EM moves toward CBME and PE, it is increasingly important that programs are able to provide assessment data from multiple sources to provide robust support determinations for resident promotion and entrustment. Clinical assessment dashboards can provide learners and faculty with one valuable source of this data,[71] and residency programs should consider leveraging their local resources and exploring relevant metrics to examine resident clinical performance (Table 3).

Dashboards should be developed and refined using multisource input from educators and trainees and implemented through an equity lens to minimize bias in assessment. Metrics included should be transparent, use clear and consistent benchmarks (such as de-identified peer comparison) for target performance, align with institutional and programmatic goals, and have resident buy-in.

Dashboard platform, frequency of data updates, and data visualization should be chosen based on each institution's technologic and data analytic capabilities. Program evaluation should be undertaken frequently to ensure the dashboard is continuing to meet stakeholder needs.

FUTURE DIRECTIONS

While educational experiences may be captured through quantitative data, future work may consider such innovations as applying learning analytics, artificial intelligence, and large-language models to capture the breadth and depth of learning exposure, including extractions from unstructured data in patient charts and resident medical decision making, downstream diagnoses for discharged patients, and follow-up visits.[21,72] Individual performance data can be triangulated with EHR metadata and novel technologies such as motion capture, haptics, and wearable devices.

Future dashboards could allow residents to be proactive, rather than reactive, in addressing areas of relative training deficit. For example, if the resident is identified as having seen fewer ophthalmologic complaints than peers, the resident could be nudged in real-time when a patient with this chief complaint is available for evaluation. While not a perfect solution, this would address some of the randomness of educational exposure in EM.[73] In considering the vast landscape of opportunity, we must also weigh the immense resources involved in developing this level of PE and how doing so may widen educational inequity between highly and poorly resourced institutions.

CONCLUSIONS

Personalized clinical dashboards can be a valuable part of programmatic assessment in competency-based medical education and serve as a tool for emergency medicine residents to better focus their efforts as they grow and develop their skills during training. While a substantial amount of work has already been done in the realms of metric selection and dashboard implementation, there are still areas of further study, such as trainee psychological safety and best practices of implementation, needed to ensure broad and equitable access to clinical dashboards in emergency medicine residencies.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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