

Information Gathering Report for New Measure Development (Summary Report of Environmental Scan and Empirical Analysis) for Equity of Emergency Care Capacity and Quality Electronic Clinical Quality Measure

Submitted by:

Yale New Haven Health Services Corporation – Center for Outcomes Research and Evaluation
(YNHHSC/CORE)

CORE Project Team:

Rebekah Heckmann, MD, MPH, MPA – Project Lead
Clarissa Myers, DPT, MPH – Project Lead
Karen Dorsey Sheares, MD, PhD – Project Director
Amy Moyer, MS, PMP – Director
Elizabeth Triche, PhD – Director
Tina Loarte-Rodriguez, DNP, MSN, RN, CIC, CPPS, CPHRM – Associate Director
Leianna Dolce, BS – Project Manager
Allie Stupakevich, BS – Project Associate
Doris Peter, PhD – Subject Matter Expert
Arjun Venkatesh, MD, MBA, MHS – Subject Matter Expert
Brooke Villarreal, DNP – Associate Director, Digital Product Development
Faseeha Altaf, MPH – Division Lead, Digital Health/Research & Development
Shu-Xia Li, PhD – Associate Director of Data Management & Analytics
Rose Hu, MS – Analyst

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Introduction and Intent

The Centers for Medicare & Medicaid Services (CMS) has contracted with the Yale-New Haven Health Services Corporation/Center for Outcomes Research and Evaluation (CORE) to develop a measure of equity of emergency care capacity and quality. The measure will be an electronic clinical quality measure (eCQM), titled “Equity of Emergency Care Capacity and Quality Electronic Clinical Quality Measure” (ECCQ eCQM). The primary objective of this project is to develop a measure of equity of emergency care capacity and quality that supports hospital quality improvement to reduce harm and improve outcomes for patients requiring emergency care. Emergency care capacity can be inclusive of several concepts including emergency department (ED) and hospital crowding and boarding, and this measure will be designed to align incentives and promote improved care both in hospital emergency departments and the health system broadly. The ECCQ eCQM supports CMS’ Meaningful Measures 2.0 framework by focusing on person-centered care and patient safety. It also supports CMS’ goal to transform to full digital quality measurement by 2025. The contract name is Development, Reevaluation, and Implementation of Outcome and Efficiency Measures. The contract number is HHSM-75FCMC18D0042, Task Order HHSM-75FCMC19F0002.

As part of measure development, CORE performed a literature review and environmental scan to identify studies that will inform our measure development. This review aims to identify any peer-reviewed literature, including relevant clinical guidelines, that may provide: 1) emerging evidence supporting updates to the measure’s specifications; and 2) other information relevant to the measure’s rationale, its impact (including costs, benefits, or unintended consequences), or gaps in performance.

To facilitate review, CORE searched publications that include relevant information for the ECCQ eCQM (e.g., capacity definitions, policy implications, measure rationale, impact, or gaps in performance). The goals of the literature review were to assess existing ED boarding and crowding literature broadly particularly with regard to definitions of ED capacity to inform the measure specifications of this ECCQ eCQM. The purpose of the environmental scan was to identify measures in the emergency department setting that broadly measure the concept of ED boarding and potential harm or related adverse events.

Background and Objectives

The emergency department (ED) in the United States (U.S.) plays a crucial role in providing immediate medical care to individuals who require emergent attention for a wide range of injuries, illnesses, and medical emergencies. EDs also provide a safety-net for care in most communities as an open door to a broad range of services, including medical triage, emergency medical care, trauma care, diagnostic services, procedures, coordination and referrals, public health and disaster response, and patient education and coordination of care. The ED is also a critical hub in the health system, connecting care and services between a broad array of non-hospital settings and other hospital settings, such as inpatient care. Because of this larger health system role, ED care has many potential pressure points that can impact the quality and

timeliness of and access to acute care services.

Nearly half of all hospital admissions begin with an emergency department (ED) visit. In 2018, there were an estimated 130 million emergency department visits in the United States. In 2019, approximately 22% of adults aged 18 and over had visited the ED in the past 12 months.¹ There are long-standing and worldwide concerns about parameters that impact the quality and timeliness of care in the ED, including the interplay between patients admitted to the hospital through the ED, and care quality throughout the entire hospital or health system. Due to factors such as a high volume of patients, insufficient number of ED healthcare workers, and lack of resources, the ability to provide timely care is often impeded due to crowding in the ED.² Crowding is defined by the American College of Emergency Physicians as a time when the identified need for emergency services exceeds available resources for patient care in the ED, hospital, or both.³ By 2016, the ACEP described the urgent nature of ED crowding, with greater than 90% of EDs routinely experiencing crowding conditions.⁴

A crowded ED often leads to ED boarding, which is defined by the ACEP as “the practice of holding patients in the ED after they have been admitted to the hospital, because no inpatient beds are available.”⁵ ED boarding and crowding are public health crises that negatively impact the quality of patient care including but not limited to patient experience, timely treatment, and outcomes including patient safety events and mortality. The ACEP describes other problems that result from boarding including treating patients in areas not designated for treatment, treatment performed by ED nurses, EMS diversion time, and decreased staff satisfaction.⁶ A mismatch in capacity and flow through the hospital system perpetuates the ED boarding and crowding crisis. One study found that when hospital occupancy was greater than 85%, boarding exceeded the Joint Commission’s 4-hour standard. Measurement of this crisis has not been standardized in a way that effects change, and while there are many cited interventions that improve boarding metrics, none solve the problem or address the capacity mismatch. To further explore this crisis, an extensive literature review and environmental scan were performed.

Objectives of this ES/LR include: (1) informing the direction of future measure development by examining current literature documenting ED boarding and crowding as it relates to quality and harms; (2) defining ED capacity metrics of boarding and crowding; and (3) identifying existing measures related to ED boarding and crowding.

Methods

Literature Review Methods

For the literature review, CORE identified peer-reviewed publications related to the ECCQ eCQM by searching Ovid Medline[®] for articles published between January 1, 2018, and March 9, 2023. Key terms were identified from keywords pertaining to ED boarding and crowding. CORE performed a search of capacity definitions, outcomes, practice setting, the keywords listed below using structured Medical Subject Header (MeSH) terms to identify indexed publications, and keywords searches using title, abstract, and publication terms to identify recent

publications not yet indexed. The search strings, Boolean operators, and limits used to implement the search strategy for the articles are included in [Appendix A](#).

CORE's measure development team, including clinical staff, reviewed each abstract to determine its appropriateness for inclusion. Articles that met one or more of the following exclusion criteria were excluded:

- Study protocols for randomized controlled trials
- Full text not available, and information in abstract insufficient
- The primary focus was a population, intervention, or topic not related to the ECCQ eCQM concept; and/or
- Literature not available in English.

Four CORE team members reviewed all articles, tagged key words, and applied the above exclusion criteria. Next, one CORE team member reviewed the excluded articles and confirmed their exclusion. The same CORE team member also re-reviewed the included articles for inclusion, which were then abstracted for the following variables: dataset and sample, study design, main findings, and limitations.

Environmental Scan Methods

The environmental scan included a review of web-based sources of information to identify measures related to the ECCQ eCQM topic. We utilized a standard approach developed by CORE to be consistent with the CMS Measure Management System Blueprint that relies on pre-specified websites and search engines. Our search aimed to identify measures examining ED crowding and boarding, resulting harms, ED interventions, and definition of capacity metrics that may be related to or compete with the measure under development.

We searched the quality measure reporting and measure repositories and pre-rulemaking measure lists and reports that are listed below, and where appropriate, used the following keywords: "emergency department," "emergency department boarding," "emergency department crowding," "emergency department length of stay," "bed occupancy," "crowding," "boarding," "emergency room," "over-crowding," "throughput."

- National Quality Forum (NQF) Quality Positioning System (QPS): <https://www.qualityforum.org/QPS/>
- CMS Measure Inventory Tool (CMIT): https://cmit.cms.gov/CMIT_public/ListMeasures
- CMIT Environmental Scan Tool: https://cmit.cms.gov/CMIT_public/EnvironmentalScanAbout
- CMS Pre-Rulemaking MUC Lists and Recommendation Reports: <https://mmshub.cms.gov/measure-lifecycle/measure-implementation/pre-rulemaking/lists-and-reports>
- QualityNet: <https://www.qualitynet.org/>
- Quality Payment Program: <https://qpp.cms.gov/mips/explore-measures> and the [2023 Qualified Clinical Data Registry \(QCDR\) list of measures](#)

- National Committee for Quality Assurance (NCQA): <https://www.ncqa.org/>
- Association of State and Territorial Health Officials (ASTHO): <https://www.astho.org/>
- The American College of Emergency Physicians (ACEP): <https://www.acep.org/>

To identify any additional measures not found in the above sources, we conducted Google™ and Google Scholar™ searches for the same [keywords](#) listed above and we reviewed the first three pages (30 links) for each search.

We excluded measures that were qualitative, not endorsed, or active, did not focus on the ED setting, and did not focus on a measurement of ED boarding.

We abstracted the following variables for each measure identified: measure title and steward, status of CBE endorsement, data source, cohort, outcome, participation requirements, measurement window, statistical model, risk-adjustment variables, and public reporting status.

Literature Review Results

Our literature review resulted in 130 unique articles that met our inclusion/exclusion criteria relevant to the ECCQ eCQM measure objectives. The final search yielded 1,670 unique articles, 1,540 of which were excluded based on the criteria above. Below, we describe key features and themes of these articles by topics: capacity metrics, harm, special populations, and interventions.

Of the articles included, 44 were retrospective cohort, 17 were systematic reviews, two reviews of systematic reviews, five prospective cohort, seven interventions, seven observational, and seven reviews. Some of the other study types included matched cohorts, modeling and simulation, validation, cross sectional, case studies, and surveys, all of which are documented in a separate document.

Capacity Metrics: Descriptions and Definitions

ED boarding and crowding are a world-wide problem though there is no gold standard measurement to outline ED capacity as it relates to ED crowding and boarding. There are exhaustive lists of metrics used singularly or in composite that attend to ED capacity and boarding. The most studied simple crowding measures included ED occupancy, ED length of stay, and ED volume; boarding time is commonly studied and defined, but heterogenous in measurement as different time points are used in analyses. More complex composite measures are also studied. The ones identified in this literature review include Except for the National ED Overcrowding Scale (NEDOCS), the Emergency Department Work Index (EDWIN), the International Crowding Measure in Emergency Departments (ICMED), Real-time Emergency Analysis of Demand Indicators (READI), and Emergency Department Crowding Scale (EDCS).^{7,8} One systematic review of 46 papers explored four databases relating to crowding in the ED, of which 71 unique crowding metrics were identified. This literature review focused on those most pertinent to actionable quality measurement of ED crowding.⁹

Simple throughput metrics, such as ED length of stay (LOS), occupancy, waiting room times, and boarding times, were used and evaluated often, as they are simple to use, and evidence supports their validity in measuring ED crowding and boarding. Comparatively, more complex composite metrics like EDWIN or NEDOCS may be utilized. The formula used in EDWIN measures the ratio of workload to work capacity and includes the following variables: the number of patients in the ED in triage, number of attending physicians on duty, the number of treatment bays, and the number of admitted patients in the ED. The formula in NEDOCS reports a score with the following variables: the number of ED patients, the number of ED beds, the number of hospital beds, the number of ventilators in use in the ED, the waiting time for the longest admission, the waiting room time of the last patient called to bed, and the number of admits in the ED.⁹ Boarding time is not unanimously measured, for example it may be calculated at time of inpatient order, or based on a threshold of boarding time (two, four, or six hours) after decision to admit.¹⁰ Boarding time has also been analyzed with consideration to various demographic variables, including race, gender, age, and clinical status.¹¹ ED length of stay (LOS) and occupancy were the strongest predictors of worse quality of care across different care domains, and identified as the most persuasive and impactful to measure.^{12,13} Another study assessed which throughput metrics were most strongly associated with a re-visit to the ED within 72 hours after ED discharge. ED occupancy was found to have the strongest association, followed by ED waiting room time and boarding times.¹⁴

In an effort to validate and identify a gold standard, many researchers have compared various metrics that measure ED crowding and boarding. EDWIN and NEDOCS were compared at one hospital, to best identify the predictor of crowdedness, as compared to average LOS in the ED; EDWIN offered the most predictive power for changing ED conditions, but NEDOCS was still useful alongside to detect crowding. Both of these measures, suggested for use alongside a threshold alert system, would alert ED management to an unusual increase in crowdedness.¹⁵ NEDOCS was compared against ED occupancy rate, defined as the number of full ED beds over the number of available ED beds, concluding that occupancy rate was as accurate as NEDOCS and well-correlated to the ED staff perception.¹⁶ A study conducted outside of the United States compared EDWIN and EDANS, READI, and NEDOCS with ED physician and nursing perception, with NEDOCS and READI reporting the highest level of correlation among staff perception.⁸ Another study compared NEDOCS and EDWIN, noting that EDWIN was less sensitive in distinguishing variations in the ED, and they generally had low correlation; perhaps their use combined could better evaluate the ever-fluctuating status of an ED.¹⁷

Modified versions of the longer measurement tools have also been explored. Modified NEDOCS (mNEDOCS) was validated against ED staff perception of crowding, and there was strong correlation noted between mNEDOCS and perceived crowding, supporting the use of a modified version for a fully automatic real-time crowding measure. (921) A short ICMED, that removed 'left without being seen' (sICMED) was externally validated against physician's perception of crowding and found to have moderate face validity at predicting concerns about crowding and

safety.¹⁸

In conclusion, there are extensive options for measuring ED crowding and boarding, and the differences in measurement highlight the challenges including definition and measured outcomes. Furthermore, the research included in this literature review was predominately retrospective and the ED is a dynamic, rapidly changing setting, even minute to minute in each ED, which further highlights these measurement challenges.

Harm

ED boarding and crowding are important public health issues that have been associated with various adverse events, most concerning for patient outcomes, though some mixed evidence on mortality has been published. Adverse events and harms identified in this literature review include mortality (in-hospital, 10- and 30- day mortality), delay in antibiotic administration, delay in medication administration, higher complication rates, poor patient experience and satisfaction, and generally poorer quality of care.^{19,20,21,22} A systematic review including 102 articles explores a non-exhaustive list of harm to patients that also include increased exposure to error, negative effects to staff (including stress, violence exposure, and poor adherence to clinical standards at high crowding times), and system level consequences related to poor flow through the health system leading to increased LOS for both ED and inpatient visits.²³ Length of time waiting in the ED, boarding time, and ED LOS increase the odds that a patient will experience an adverse event while in the ED.^{24, 20} Even more than ED occupancy, hospital occupancy greater than 85% was also associated with an increased boarding risk beyond a four-hour threshold.²⁵ These prolonged times to treatment directly relate to the quality of care provided. Furthermore, mortality is a highly studied adverse event that has been associated with ED boarding; various studies cite increased risk of (10-day)mortality, based on acuity level assigned at arrival, and when ED occupancy ratio increased.^{22,18} Another review of ED crowding cited worse quality of care in 75% of the included studies, worse perception of care in 100% of included studies, and higher mortality in 45% of the included studies.⁷ Prolonged ED wait times and ED LOS is likely an important link between ED crowding and mortality, but maximum occupancy rates in the ED, which suggest the most chaotic time in an ED, are also associated with sudden in-hospital cardiac arrest.^{26,27}

Alternatively, there is mixed evidence in many systematic reviews between ED boarding and harm. One systematic review concluded that ED crowding's association with adverse events and health outcomes to be less clear.²⁸ A 2022 systematic review identified 19 studies that examined the relationship between ED LOS and mortality, and 10 out of 19 studies found no association (positive or negative).²¹ In that same study, only four out of 11 studies showed a clear relationship between boarding and mortality.²¹

Health Equity: Special Populations

Apart from the general harms described in the previous section, ED boarding and crowding have also been noted to be uniquely harmful to specific vulnerable populations, namely behavioral

health patients and geriatric patients, who tend to suffer more significant harms when boarding when compared with other populations. Among the 130 unique articles identified in this literature review, 17 of these (non-interventional) articles focused specifically on issues related to these vulnerable populations, with the majority of these articles dwelling on harms associated with behavioral health patients.

Many of the barriers to providing high quality care for behavioral health patients are acutely exacerbated in crowded clinical settings. For example, limited space, limited time, and “difficulty differentiating between psychiatric illness and social disorganization” can all become more complicated to address during times of boarding.²⁹ Moreover, the act of boarding itself can present an additional harm that can contribute to downstream negative clinical outcomes during a patient’s inpatient hospitalization; one of the studies identified during our literature review found that boarding “was associated with a high probability of increasing the hospital length of stay for psychiatric patients,” in addition to contributing to the need for administration of additional doses of antipsychotic and sedating medications when compared with similar patients who were not boarding.

Although numerous harms are particularly relevant to the care received by older patients in emergency departments, the impact of delirium is noteworthy among these harms, with “between 6% and 38% of older ED adults [having] incident delirium, defined as new development of delirium after arrival [in the ED].”³⁰ In addition to being an independent predictor of death within six months, delirium has also been associated with a host of other serious harms, including increased length of hospitalization and decreased independence and cognitive function; notably, a systematic review of 11,900 articles identified few interventions that consistently reduced incidence or duration of delirium in the ED, indicating the importance of preventing boarding and other key factors that cause delirium in this cohort.³¹

Finally, it is worth noting that, apart from behavioral health and geriatric patients, there are other vulnerable populations, including pediatric patients, that are certainly impacted by boarding and crowding in the ED, even if development of a measure directed specifically at these populations may fall outside of the scope of this literature review. One cohort study identified longer ED boarding times between Black and White patients alone, and for Black patients admitted for psychiatric visits.¹¹ Since 2017, the largest increases in ED visits for suicidal ideation have occurred for pediatric patients and older adults. Of concern, ED leaders often feel particularly poorly equipped to treat patients from these cohorts.³² Additionally, disparities in care have been noted among patients who are assigned a lower triage acuity level during times of ED crowding and among Black patients who are boarded for a psychiatric admission.^{33,34}

Interventions

The focus of this literature review was to identify all encompassing literature to inform measure development, which included interventions that aimed at reducing ED crowding and boarding and increasing equitable ED access and reducing harm. Understanding these interventions as

they relate to patient and clinical outcomes can help inform the direction of measure development. Various and extensive interventions are cited covering different processes, clinical care access points, and creative methods of tending to the ever-growing ED boarding problem; some examples of interventions that have been considered include care transitions, point-of-care testing, observation units, streaming, short-stay units, or administrative or organizational improvements.^{35,36,37} Other studies suggest specific direction including strengthening triage and ED teams, creating new care zones, or use of capacity protocols.³⁸ Several studies also cite the benefit of adding ED staffing, such as an additional ED physician per shift, or adding nurse practitioner or primary care physician to staff to manage less emergent cases.^{38,39} Other studies cite different points of care to enact change; one study assessed telehealth to manage non-critical emergencies in rural settings to reduce unnecessary patient transfer and increasing capacity of ED staff to diagnose and manage patients locally; another study employed a nurse navigator to assist in decreased turnaround time for EMS.^{40,41}

The extent of literature describing specific interventions trialed in hospitals and health systems to attend to ED boarding, as described above is widely explored and creative. There is so much variety between patient populations, health status and comorbidities, and case-mix, that no one intervention will solve the ED boarding crisis. Further, disparities among care patients receive also contribute to different interventions and subsequent outcomes: one intervention evaluated assignment to fast-tracked beds versus a regular ED bed based on acuity scores, and black patients were more likely to be given fast-tracked status, wait longer in the waiting room, and be classified as lower acuity than matched white counterparts.⁴² Such differences need to be considered when deciding implementation of interventions, though that is not the focus of this literature review or quality measure.

In conclusion, ED crowding and boarding are the focus of the problem, but there is widespread impact and influence between an ED and a hospital and/or health system. The interventions described above are inclusive, but not nearly exhaustive, of efforts to reduce crowding and boarding within the ED. System wide change is ultimately necessary to respond to this crisis.⁴³

Environmental Scan Results

Measures: Active

Our environmental scan identified six existing measures that are potentially related to ED boarding:

- 1) Appropriate Treatment Time for ST-Segment Elevation Myocardial Infarction (STEMI) Patients in the Emergency Department (ED)
- 2) All-Cause Emergency Department Utilization Rate for Medicaid Beneficiaries in Need of Integrated Physical and Behavioral Health Care
- 3) Ambulatory Care: Emergency Department Visits
- 4) ED Median Time from ED Arrival to ED Departure for all Adult Patients
- 5) ED Median Time from ED Arrival to ED Departure for all Pediatric Patients
- 6) Door to Diagnostic Evaluation by a Provider Within 30 Minutes – Urgent Care Patients

Below we describe key features of these measures.

Measure Stewards and NQF Endorsement

Two of the six measures are stewarded by the Centers for Medicare & Medicaid; the third measure is stewarded by the National Committee for Quality Assurance (NCQA). The remaining three are stewarded by the ACEP and included in the Merit-based Incentive Payment System (MIPS). All are currently endorsed.

Cohort Definition

Five of the six active measures include only adult patients; Ambulatory Care: ED Visits is included in the home health set as well as the child core set, and the ED Median Time from ED Arrival to ED Departure measures adult and pediatric patients.^{45,47} The numerator of each measure defines specifics about quantifying: the time to appropriate treatment for arrival of STEMI patients to the ED; and the number of ED visits resulting in an inpatient or observation stay for non-dual eligible Medicaid beneficiaries; and the number of ED visits, counted regardless of the intensity or duration of the visit. ED Median Time from ED Arrival to ED Departure measures the time in minutes for discharged patients.^{44,45,47} Door to Diagnostic Evaluation measures the percentage of urgent care patients who contacted a provider within 30 minutes of arrival.⁴⁷ Greater detail of the numerator, denominator, and denominator exclusions for each measure can be found in details of the measure specifications.^{44,45,46,47}

Description

The measures are described below:

- The percentage of ED patients with diagnosis of STEMI that receive appropriate and timely treatment.
- Number of all-cause ED visits per 1,000 beneficiary months among adult Medicaid beneficiaries who met the eligibility criteria for any of the four denominator groups (cite)
- Rate of ED visits per 1,000 beneficiary months among children up to age 19.
- Time (in minutes) from ED arrival to ED departure for all adult or pediatric patients.
- Percentage of urgent care patients who contact a provider within 30 minutes of arrival.

Past Measures: Retired or Proposed for Removal

In addition to the existing measures identified above, there are four noteworthy measures that have been retired from use in quality reporting programs by CMS.

The following measures were previously included in CMS Programs or have been proposed for removal:

- OP-18: Median Time from ED Arrival to ED Departure for Discharged ED Patients. This measure calculated the median time from ED arrival to time of departure from the ED room for patients discharged from the ED (Hospital Outpatient Quality Reporting, HOQR).⁴⁸

- OP-20: Door to Diagnostic Evaluation by a Qualified Medical Professional. This measure calculated the time from ED arrival to provider contact for ED patients (finalized for removal for CY 2020 payment determination from HOQR).⁴⁹
- OP-22: Left Without Being Seen. This measure calculated the percentage of patients leaving the ED without being seen by qualified medical personnel (proposed for removal from HOQR in the 2024 Outpatient Prospective Payment System Proposed Rule).^{50,51}
- ED-2: Median Admit Decision Time to ED Departure Time for Admitted Patients. This measure calculates the concept of boarding, from the time the decision is made to admit a patient from the ED to the time they depart the ED for an inpatient bed. This measure was in public reporting from 2013 until 2022 when it was removed for various reasons, primarily that hospitals were meeting the 6-hour threshold (Inpatient Quality Reporting).⁵²

Summary and Implications for Measure Development

The ten measures included in our environmental scan focused on different aspects of ED care that relate to ECCQ but do not fill the gap for existing measures that addresses ED care capacity. The ACEP measure ED Median Time from ED Arrival to ED Departure for all Pediatric Patients was adapted from ED-2, but does not measure admitted patients, and therefore is unable to measure boarding or the entirety of ED capacity for care. ED boarding is not well captured by any measure, although it is well documented that it adversely affects patient outcomes and quality of care, and as such, measuring this gap is the first step to addressing the problem. The various goals of these ten identified measures are distinct and differ from the purpose of the ECCQ eCQM. The four past measures (three retired and one proposed for removal) were included to provide context of quality measurement in the ED space, highlighting the historical measurement challenges in the ED setting.

Empirical Analysis

The data source is ED data from 2021 to 2022 from EDs inclusive of the Yale New Haven Health System (YNHHS), analyzed to describe general volume for feasibility analysis.

Descriptive Statistics

Descriptive statistics were first analyzed to explore our hypotheses about the ED boarding and crowding crisis. The analyses described below are intended to describe the dataset, validate initial measure concepts, determine initial feasibility, and inform next steps in measure development.

Total Daily Arrivals

[Table 1](#) shows total daily arrivals (ED volume) across all YNHHS EDs by year. Total daily arrivals are calculated using the ED arrival date within EHR data. These data show the wide variation in ED volume across different EDs in the same health system.

Table 1. Total ED volume (number of patients), by site and year (2021, 2022)

YNHHS ED	2021	2022
ED1	87,072	88,453
ED2	36,293	41,491
ED4	26,872	29,503
ED5	62,436	62,948
ED6	84,440	90,256

**ED3 and ED7 removed from all analyses due to low volumes*

Minutes in Waiting Room

[Table 2](#) shows minutes spent waiting in the ED waiting room (calculated as time between a patient’s arrival to the time they are assigned to a treatment space) across all patients seen at YNHHS EDs between 2021 and 2022. The median waiting room time was 13 minutes; the maximum time was 197 minutes (3.3 hours).

Table 2. Minutes in ED Waiting Room

Percentile	Time (in minutes)
95% Max	197
75% Q3	44
50% Median	13
25% Q1	5
5% Min	2

Time in treatment space

[Table 3](#) shows the time patients spent waiting in a treatment room (ED roomed time to ED departure time) in minutes. The median wait time is 223 minutes (3.7 hours), and a maximum wait time of 1,578 minutes (26.3 hours). This metric includes both patients who are admitted and patient who are discharged.

Table 3. Waiting Time in ED treatment room in minutes across EDs in YNHHS (2021-2022)

Percentile	Time (in minutes)
95% Max	1,578
75% Q3	406
50% Median	223
25% Q1	117
5% Min	34

ED Length of Stay

[Table 4](#) describes the total time a patient spent in the ED (or ED length of stay), calculated as the interval between ED arrival time to ED departure time, in minutes, and captures both discharged and admitted patients. The median total wait time is 268 minutes (4.5 hours), and the maximum is 1,584 minutes (26.4 hours).

Table 4. Total Waiting Time (ED Length of Stay) in minutes across EDs in YNHHS (2021-2022)

Percentile	Time (in minutes)
95% Max	1,584
75% Q3	443
50% Median	268
25% Q1	157
5% Min	56

Boarding Time

[Table 5](#) shows the distribution of boarding time in minutes across all YNHHS between 2021 and 2022, calculated by subtracting ED bed request time from ED departure time. Boarding ranged from zero minutes (direct entry to the ED) to more than 605 hours, which is just over 25 days.

Table 5. Percentage of boarding time in minutes across EDs in YNHHS (2021-2022)

Percentile	Time (in minutes)
95% Max	2,617
75% Q3	804
50% Median	269
25% Q1	144
5% Min	60

Left Without Being Seen (LWBS)

Left without being seen is defined as the time after a patient was triaged but left the ED before they were seen by a provider. [Figure 1](#) and [Figure 2](#) detail the percentage of patients left without being seen by year, by ED ([Figure 1](#)) and by age group ([Figure 2](#)). Across the EDs shown in [Figure 3](#) and across the two-year period, the proportion of patients who left without being seen ranged from about 1.1% to 4.5%.

Figure 1. Percentage of patients LWBS by a provider across EDs in the YNHHS (2021-2022)

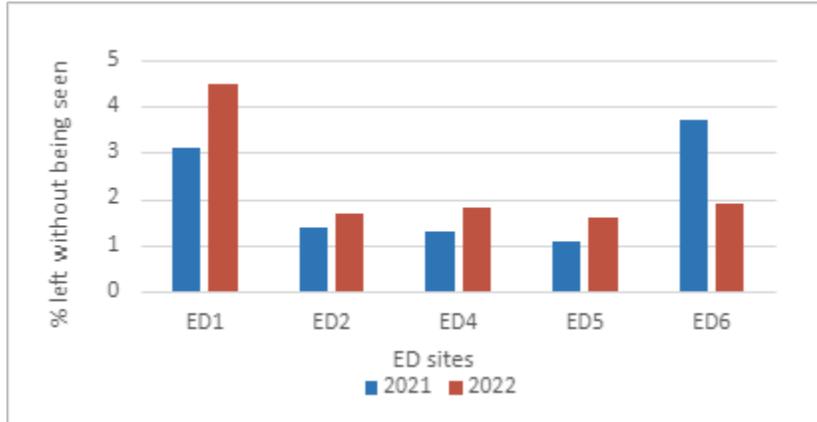
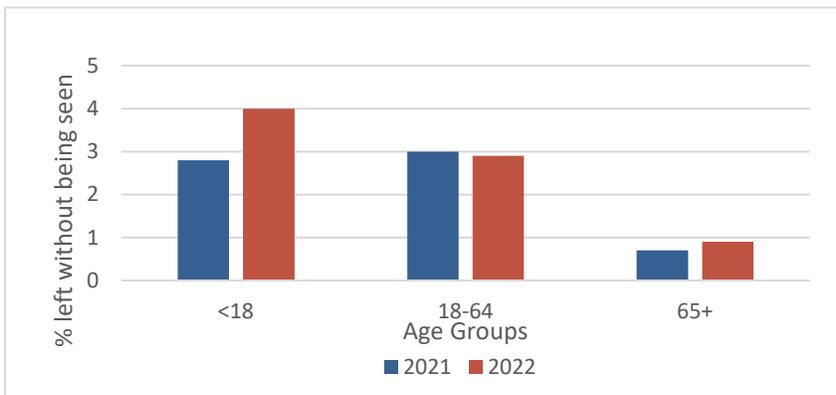


Figure 2. Percentage of patients LWBS by a provider by age group across EDs in the YNHHS (2021-2022).



Behavioral Health

[Figure 3](#) shows the proportion of total ED visits related to behavioral health by site. [Figure 4](#) shows the proportion of ED visits for behavioral health, stratified by age. Data in [Figure 3](#) and [Figure 4](#) support the importance of stratification for behavioral health; behavioral health patients are not well distributed across EDs geographically or within a health system.

Figure 3. Percentage of ED visits for behavioral health across EDs in the YNHHS (2021- 2022).

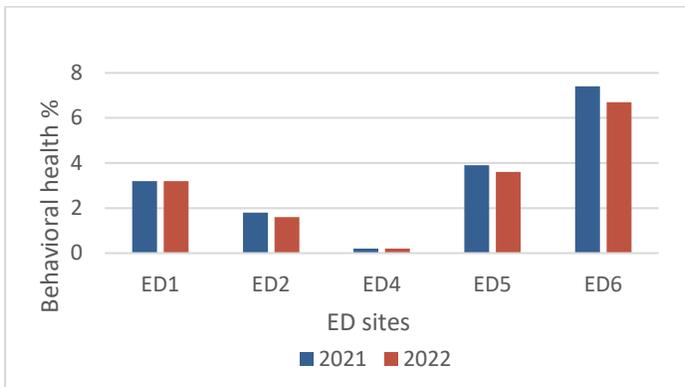
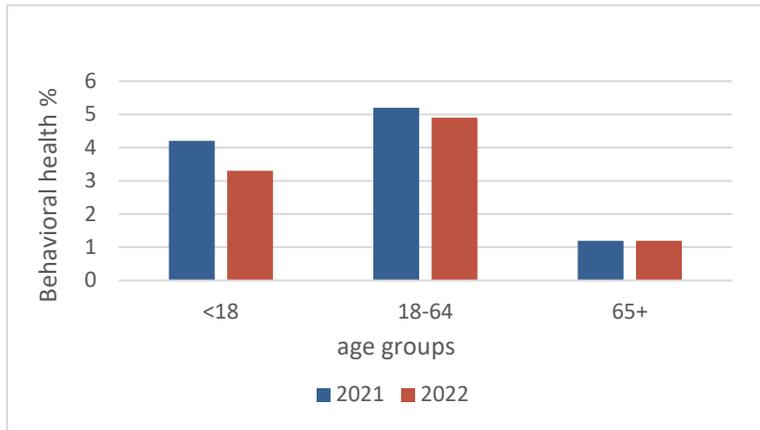


Figure 4. Percentage of ED visits for behavioral health by age across EDs in the YNHHS (2021-2022).



Conclusions and Implications for Measure Development

In this review, CORE identified 130 relevant studies, ten measures (six active, three retired, and one proposed for removal) related to the ECCQ eCQM topic. The literature extensively outlines the need for a quality measure that can best address ED care capacity inclusive of boarding and crowding, describing exhaustive lists of measures, ranging from simple throughput metrics to complex composite measures. Further, the analyses in the dataset support the findings from this review and serve to help guide the next steps in measure development.

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Appendix A. Literature Review Search Strings

The search strings were developed to identify peer-reviewed articles from the Ovid MEDLINE® database. The search included MeSH terms (auto explode [exp]), keyword searches in title (ti) and abstract (ab) fields, and publication type (pt). The search was structured and implemented using Boolean operators (AND/OR). Additionally, the publications must have been added to Ovid MEDLINE® between January 1, 2018, and March 9, 2023.

Search Strings

1. Setting
 - Emergency Service, Hospital, Emergency (department* or ward* or room*).
2. Overcrowding
 - Bed Occupancy / Crowding / Capacity Building (capacity or over-crowding or through-put or throughput)
 - Boarding
3. Measures & Tools
 - Qualitative Research/Operations Research/Retrospective Studies (research or study or studies) / Delivery of Health Care/Quality Assurance, Healthcare
4. Vulnerable Populations
 - Health Disparate/Minority and Vulnerable Populations/ Ill-Housed Persons/ Medically Uninsured (vulnerable or underserved or disadvantage or sensitive)
 - Patient Safety
 - Aged 80 and over/ Frail/Elderly/Geriatric
 - Mental Health Disorders/Behavioral Health