

CLINICAL CONCEPTS

Diversity, Equity and Inclusion

Designing and developing a digital equity dashboard for the emergency department

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Abstract

Disparities in diagnosis, treatment, and health outcomes of racial minorities are well documented in the emergency department (ED). Although EDs may provide broad departmental feedback on clinical metrics, lack of up-to-date monitoring and data availability present significant challenges to identifying and addressing patterns of inequitable care. To address this issue, we developed an online “Equity Dashboard,” incorporating data that is updated daily from our electronic medical record to highlight demographic, clinical, and operational variables, stratified by age, race, ethnicity, and language, and sexual orientation, gender identity. Through an iterative design thinking process, we created data visualizations for an interactive interface that tells a story about the ED patient’s experience and enables any staff to explore up-to-date trends in patient care. To assess and improve usability of the dashboard, we conducted a survey of end-users using custom questions, as well as the System Usability Scale and Net Promoter Score, both of which are validated health technology use instruments. The Equity Dashboard is of particular use for quality improvement initiatives, as it reflects common departmental challenges including delays in clinician events, inpatient boarding, and throughput metrics. This digital tool further helps demonstrate how these operational factors differentially affect our diverse patient population. The dashboard ultimately enables the ED team to measure current performance, to identify our vulnerabilities, and to design targeted interventions to address disparities in clinical care.

KEYWORDS

digital dashboard, digital health, health design, quality improvement

1 | INTRODUCTION

1.1 | Background

Disparities in diagnosis, treatment, and health outcomes of racial minorities are well documented in the emergency department.

Even after controlling for confounding variables such as socioeconomic status, health care disparities exist in the administration of pain medications,^{1,2,3} evaluation and management of acute coronary syndrome,^{4,5} consultation of specialists,⁶ and most recently, the burden of COVID-19 infection and related morbidity and mortality.^{7,8,9} The annual National Healthcare Quality and Disparities Report shows that significant racial discrepancies in treatment still exist, with black patients receiving worse care than white patients for almost 40% of

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quality and safety measures in 2021.¹⁰ National organizations continue to draw much needed attention to examining these inequities in health care delivery,^{11,12} and health systems in response have begun stratifying their quality and performance measures¹³ by demographic detail to identify existing disparities.^{14,15}

Although EDs may track operational metrics such as wait time, length of stay, door-to-clinician time, and other aspects of care, the lack of more frequent monitoring and data transparency poses barriers to recognizing and confronting patterns of inequity. Currently, data are typically provided in a limited format tailored only to those involved in clinical and financial operations.¹⁶ Expanding access to care metrics would allow for more regular opportunities to engage in quality improvement, especially when the clinical data focus on groups that are at higher risk of being marginalized in their care. These patient groups can be characterized by age, race, ethnicity, and language (REAL), and sexual orientation, gender identity (SOGI). Improving the availability of up-to-date data may help increase awareness and motivation to examine patterns of care for these groups.

Web-based digital solutions such as dashboards have expanded dramatically in health care as effective visual tools for health care workers outside of operations to monitor continuous data and detect variations in care.¹⁷ We developed an “Equity Dashboard” to provide a more frequent and accessible summary of patient care to allow more users to identify trends and opportunities for improvement. An optimal dashboard for our setting was designed and developed using a human-centered design thinking approach¹⁸ incorporating open interviews and end-user survey data for usability and experience. Our hope is that other institutions may learn from our process when developing similar dashboards to drive improvement projects with an equity lens.

2 | DEVELOPMENT OF THE DASHBOARD

2.1 | Setting

Zuckerberg San Francisco General Hospital and Trauma Center is a public, safety-net, academically affiliated Level I trauma center in San Francisco, California. The 59-bed Zuckerberg San Francisco General ED had 57,889 visits in 2021 and is staffed by 27 full-time faculty, 60 resident physicians (who rotate at other sites), and 13 advanced practice clinicians. Our ED treats a diverse and underserved patient population: most patients (85.5%) have public or no insurance, almost a quarter (23.7%) experience housing insecurity, and 30% have limited English proficiency (LEP).

Our project team consisted of ED faculty, resident and fellow trainees, and medical students, with design assistance from a digital product studio at the University of California San Francisco (UCSF) School of Medicine, data visualization consulting from the UCSF Library’s Data Science Team, and data analysis expertise from the San Francisco Department of Public Health. This multidisciplinary team met weekly from April 2021 to April 2022 to conceive a series of variables to prioritize in our dashboard prototypes and incorporate feedback from users.

2.2 | Dashboard design process

We used design thinking methodology to build, test, and develop a web-based digital platform that automatically updates every morning from the ED electronic medical record (EMR) (Epic Systems Corporation, Madison, Wisconsin, USA). A design thinking approach is an iterative process centered on the user and employs rapid prototyping to increase usability of products in the health care setting.¹⁹ There were 2 key aspects of this process: first, we conducted rapid reviews²⁰ of literature and open interviews with key stakeholders to identify patient and clinical variables for prototyping the dashboard; and second, we sought feedback from users through a quantitative survey. This design process occurred over a period of 12 months.

Interview participants consisted of key stakeholders including clinicians, nurses, researchers, and leaders from the ED quality improvement, clinical operations, and diversity, equity, and inclusion committees. We used a purposive sampling technique to approach these stakeholders and conducted semistructured interviews with evolving open-ended questions. These questions consisted of their approach to interpreting clinical data and any unique considerations to understanding our patient population. We then used surveys to gather more information from end-users to improve the usability and perceived usefulness of the dashboard tool.

Overall, the design team aimed to “tell the story” of ED patients through the data. We focused on who comes to the ED, their time course, and the care they receive while in the ED. To select the patient variables describing who comes to the ED, we conducted a rapid review of the literature to determine best practices for identifying relevant patient demographic and health-related characteristics including age, REAL, and SOGI details. These patient groups historically have been shown to experience disparities in care and are categories widely used in public health reports.^{21,22} Insurance status, housing status, and reported zip code were also included based on feedback from our interview participants. In our setting, patient details are collected by a registration team during either the ED encounter or prior encounters within the health system and then stored in the EMR. All hospital staff are required to complete basic training modules on racial equity, sexual orientation, and gender identity. At the time of our work, there was no formalized process for quality review in place for registration staff who collect REAL/SOGI variables, but their training consisted of onboarding with standardized forms for obtaining these details from patients, including language on how questions are ideally asked. Data definitions, codings, and groupings are defined by the San Francisco Department of Public Health.^{23,24}

Clinical outcome variables were selected based on literature review of quality measurements and operational variables similar to those monitored nationally in other EDs. These variables were then organized into 3 domains. First, we focused on variables related to individual patient flow, such as means of arrival and time to triage, room, first clinician, and disposition. Second, we identified clinical variables related to diagnosis and treatment, including acuity of condition at triage, specific laboratory tests, electrocardiogram, imaging studies,

and specialist consultations. The dashboard further records activation of resources for trauma, stroke, and cardiac catheterization and the use, route, and timing of antibiotic and analgesic medications. Third, we presented metrics relevant to departmental operational throughput: type of disposition, ED length of stay, burden of inpatient boarding (patient with decision to admit but holding in the ED for >120 min), and discrepancies between initial triage and ultimate disposition (ie, low acuity patients transferred to ICU, high acuity patients discharged home). We asked our interview participants to also brainstorm and rank these clinical outcome variables to determine that those selected would be the most relevant and impactful pilot measurements for our setting, accounting for limitations in data fields accessible through our EMR.

All selected variables were collected and stored securely in our institution's intranet. We used Tableau data visualization software (Tableau Software Version: 2019, Mountain View, California, USA) to develop the interactive dashboard. To maximize ease of use, we decided to house the tool within a larger web-based digital hub designed for daily use by our department staff and accessible through a direct link from our EMR interface.

2.3 | Usability testing

Four months after the launch of the Equity Dashboard, we conducted an anonymous, cross-sectional survey of emergency clinicians asking them to recall their knowledge and confidence before the dashboard deployment and compare that with the new Equity Dashboard. The survey was distributed on the Qualtrics survey platform (Qualtrics Software Version: March 2022, Provo, UT) during a 4-week period from April to May 2022, to Zuckerberg San Francisco General ED full-time attending physicians (27) and resident physicians (60), with participants recruited by in person and email outreach. Participants received a \$5 gift card. An additional non-responder survey was not pursued.

We used previously validated health technology use instruments, when possible, including the System Usability Scale (SUS), which assesses for usability aspects, and Net Promoter Score (NPS), which reflects perceived usefulness of the digital intervention.²⁵ The SUS consists of a standardized 10-item questionnaire with 5 response options: strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, and strongly agree. We also adapted questions in the domains of dashboard understandability, navigability, ease of use, usefulness, and frequency of use to create a more comprehensive quantitative survey (Appendix 1). The NPS is a gold standard market research metric based on a single question asking how likely a user would recommend an organization, product, or service to a friend or colleague. It is answered on a 0-point (not at all likely) to 10-point (extremely likely) scale. Depending on the response, users are categorized into 3 categories: promoters (score of 9 or 10), passives (score of 7 or 8), or detractors (score of 0 to 6). The ultimate NPS value is calculated by subtracting the percentage of detractors from the percentage of promoters, which can range from the lowest -100 (if every

respondent is a detractor) to the highest of 100 (if every respondent is a promoter).

Results from this survey were used to measure product engagement and to refine the Equity Dashboard through ongoing cycles of improvement, a key component of the design thinking process. Collecting this feedback enabled the project team to improve the usability and usefulness of the dashboard, ultimately including additional visualizations on the geographic variation of our patients upon completion of the pilot. The dashboard creation and data collection were deemed exempt by the University of California, San Francisco Institutional Review Board (Study #21-35113), and access is available only with secure login similar to that used for the EMR.

3 | RESULTS OF THE DASHBOARD DESIGN PROCESS

Through the process of identifying patient and clinical variables to include in the dashboard, our team learned that users preferred information to be displayed from a global perspective and then narrowed to specific variables. This funnel guidance through the data allowed the user to navigate and digest the information more intuitively. The main homepage (Figure 1) of the dashboard thus characterizes the entire ED population, narrowed by arrival date. Users can then navigate to different tabs with more specific clinical outcome variables.

We also discovered that users had difficulty tracking change in clinical outcomes over time when looking at month-by-month data. It would be easier to read and compare a patient's chronological journey through the ED in an episode of care (Figure 2). We attempted to tell a story about the patient by creating a linear, horizontal timeline with different time stamps indicating the patient's care experience. That experience can then be filtered to specific patient groups by arrival date, means of arrival, triage acuity level, age, and disposition.

Finally, we found that from January 1, 2022 to March 28, 2023, there have been 3237 unique views of the Equity Dashboard. Almost a third ($n = 996$, 30.8%) of those views were from 11 high-volume users.

The surveys provided further input on opportunities to address perceived barriers to use and referral of the dashboard. We achieved a survey response rate of 33.3% ($n = 29$ out of 87 participants). The results (Figure 3) reflected overall ease of use with need for only minor improvements (SUS score of 73.2; minimum 47.5, maximum 92.5). An SUS score >68 is considered above average in overall measure of system satisfaction and sub-scales of usability and learnability. Respondents reported that they are likely to refer colleagues to the Dashboard (NPS score 20.7, Figure 4). NPS can range from -100 to 100, and values >0 indicate that respondents are more likely to be satisfied and promote the product. A higher value corresponds to a higher level of user experience and satisfaction. An initial NPS of 20.7 indicates that our users are more likely to promote and recommend the product than to criticize the product, but there is still room for improvement. All but 1 respondent learned something new from the dashboard, and 77% felt that the dashboard enhanced their understanding of patients' ED experiences. Overall, 70.4% of surveyed clinicians planned to change parts

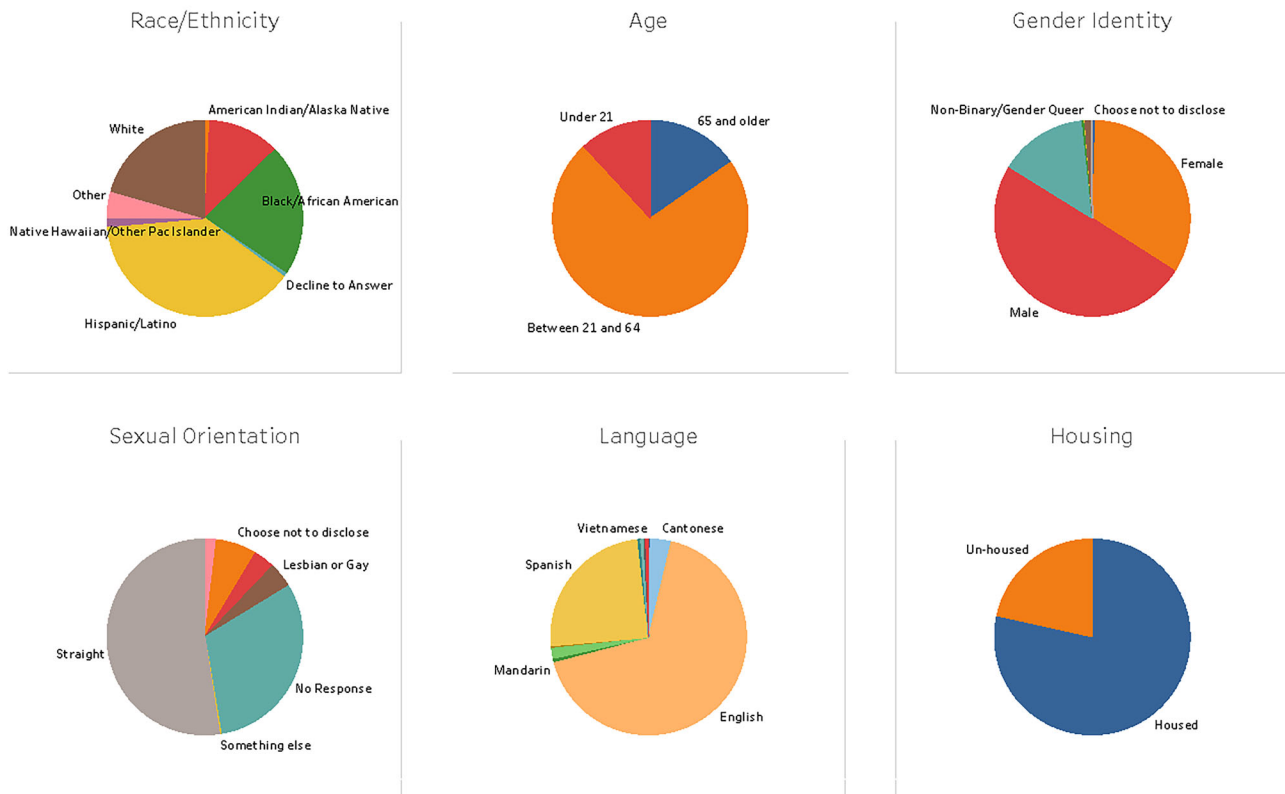
ED Arrival Date
 1/1/2022 to 12/31/2022


FIGURE 1 Homepage of the equity dashboard. The homepage shows a snapshot of who our patients are. Our patients are 22.8% Black, 21.5% White, and 4.5% other. More than a third (36.5%) identify as Hispanic/Latino. Thirty percent of patients have limited English proficiency, with Spanish and Cantonese as the most common primary languages, followed by Tagalog, Toishanese, Vietnamese, Mandarin, and Russian. The dashboard reveals that 37.9% of patients identify as male, 24.9% as female, and 2.0% as transgender, nonbinary, or other. Additional social details about our patients reveal that 85.5% have public or no insurance, 23.7% experience housing insecurity, 27.3% have sought emergency care related to mental health issues, and 30.4% have sought emergency care related to substance use.

of their practice based on what they learned from the dashboard. Free response feedback on areas for improvement included further exploration of the limitations of EMR data and building additional options for demographic breakdown, particularly within the pediatric patient population.

4 | DISCUSSION

We successfully designed, built, and implemented a digital Equity Dashboard that was used by clinicians in a public tertiary ED. The Equity Dashboard enables all emergency clinicians and staff to explore up-to-date trends in our patient care based on age, REAL, and SOGI variables; to generate and test new hypotheses; and to explore targeted interventions for quality improvement.

There are several limitations to our pilot experience. Although our dashboard allows for up-to-date data monitoring and visualization, statistical testing that incorporates confounding variables is crucial to avoiding inappropriate inferences. In addition, the dashboard data may be limited by manual input into the EMR: demographic details

of patients, from which the dashboard's categorical groupings derive, are entered by registration administrators and can be edited by any user with access to the EMR, including the patients themselves. When multiple identifying categories are reported by a patient, the first recorded one is what is used in the data presentation. This process may introduce errors and selection bias in the underlying data and subsequent analyses. Additionally, most of the outcome variables selected for this dashboard were among those already collected by our department's quality improvement and clinical operations teams, and data fields available for query through our EMR. This approach is pragmatic, but may introduce a reporting bias. Expanding these variables in the dashboard to include other novel outcomes would help investigate broader care disparities. There are also nursing protocols for labs or imaging studies for certain patient presentations that can be ordered in triage before being evaluated by an emergency physician; exploring these order patterns may also reveal protocol limitations or biases. Finally, one of the goals of the dashboard was to increase access to data and transparency for diverse stakeholders, but the assessment in this report was only administered to clinicians and not the entire staff. Future development of the dashboard would

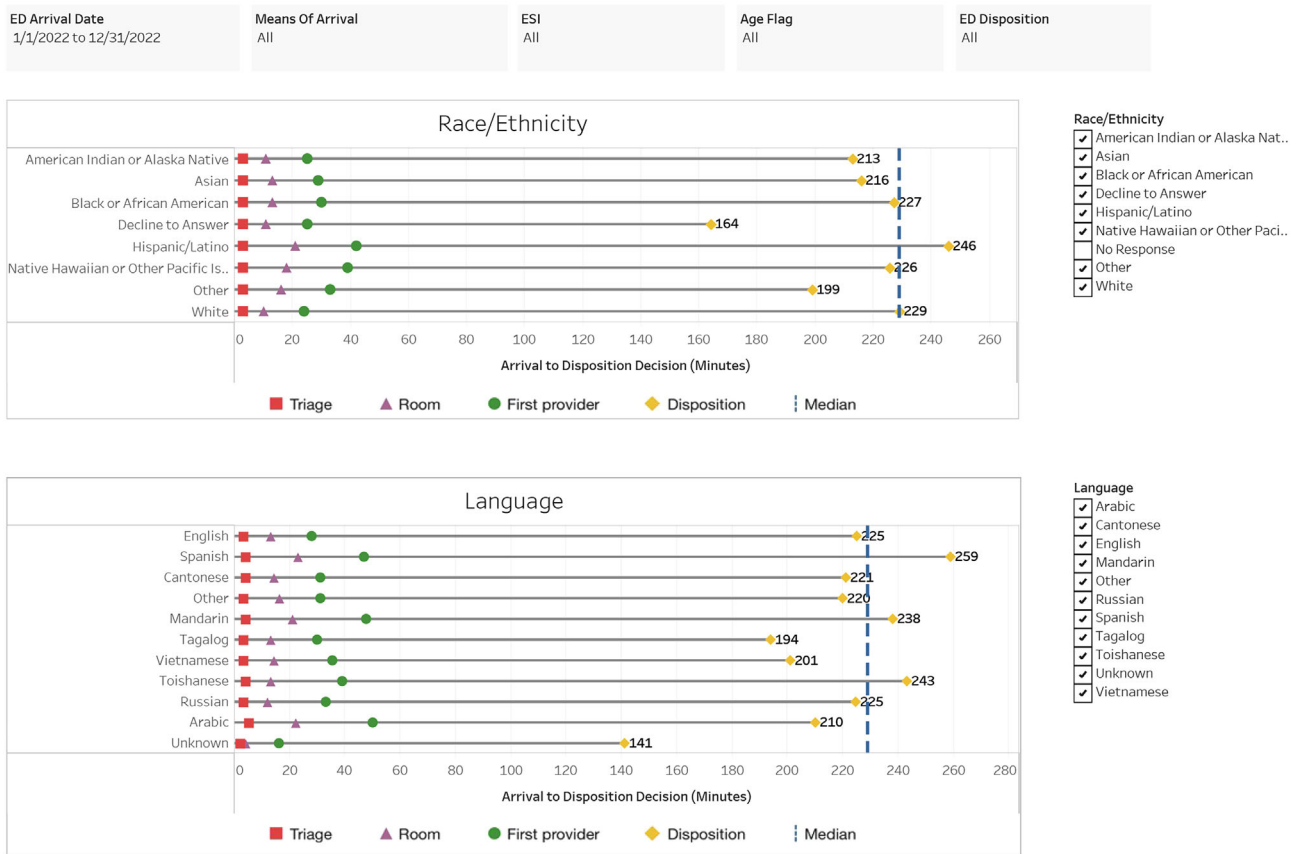


FIGURE 2 Visualization of the patient chronological experience through the ED. On this page, the user can follow the experiences of patients through the ED. The dropdown menus at the top of the page set filters by arrival date, means of arrival, triage acuity level, age, and ultimate disposition. In the boxes below, the tables document each patient group’s experience through the ED, with time to triage, room, first clinician, and disposition, measured in minutes. The median bars represent the median disposition time for all patients. This horizontal visualization of the ED course allows for users to “read” the patient experience linearly and chronologically from left to right. Selecting variables on the right side of each box can build the table to compare different group categories. Abbreviation: ED, emergency department.

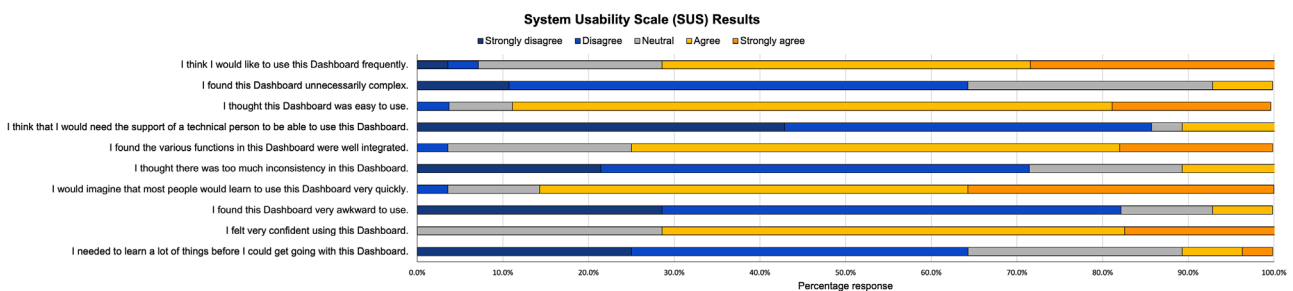


FIGURE 3 System Usability Scale (SUS) survey results. There were 10 questions in the survey assessing SUS. There was an overall SUS score of 73.2, with a minimum of 47.5 and maximum of 92.5. The majority of respondents (88.5%) thought that the dashboard was easy to use.

benefit from expanding the assessment to other staff members as well.

Nonetheless, the dashboard provides a high-level overview of our department’s care environment and practice with an explicit lens on health equity. It expands access to more frequently updated clinical data to increase transparency, and it communicates the differential

experiences of our patients by stratifying data by demographic detail. Although preconfigured reporting tools such as the Epic SlicerDicer can be applied to analyze care disparities, the dashboard model allows for continuous data monitoring. By further filtering these clinical outcomes by REAL and SOGI, the dashboard empowers clinicians and leaders with a dynamic reflection of on-the-ground care disparities.

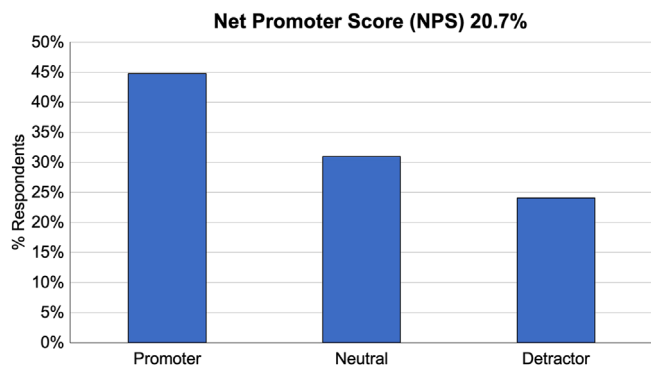


FIGURE 4 Net promoter score (NPS) 20.7%. Respondents reported that they are likely to recommend the dashboard to colleagues based on a NPS score of 20.7.

Although departmental quality improvement and clinical operations teams report select ED metrics as part of yearly reporting requirements, the dashboard provides a digital tool for examining these data with a built-in equity lens in daily management of the ED.

Our design process and implementation revealed several valuable insights that may assist in the development of similar tools within and beyond our institution. The potential benefits of increasing access to our data include engaging a more diverse set of stakeholders in examining our ED's care, investigating observational hypotheses from our own setting, and encouraging active management of any patterns in care disparities with measurable variables. For interventions to be most successful, they must draw on specific organizational, historical, cultural, and geographic contexts and patient populations.²⁶ Literature on reducing health disparities similarly notes the importance of culturally tailored interventions.²⁷ Designing with user input and diverse stakeholders from the start can improve resultant adoption and satisfaction. Developing our dashboard in an iterative process with emergency clinician focus groups helped create a product tailored for ease of use, with a high likelihood-to-recommend score. By understanding our own data and patient care, we hope to encourage curiosity and accountability in providing more equitable care in our ED. Moreover, our dashboard leverages the existing data infrastructure in our ED and can be applied to different contexts within our institution to facilitate meaningful partnerships with departmental leaders and clinical operations staff.

The Equity Dashboard facilitates data access and visualization of clinical and demographic trends in the ED. Our experience demonstrates that such data are welcome and could motivate changes in clinical practice. This digital tool is of particular use for quality improvement, as it reflects common departmental challenges including delays in clinician events, inpatient boarding, and throughput metrics. Importantly, the Equity Dashboard can help demonstrate how these operational factors differentially affect our diverse patient population.

Recognizing the existence of disparities in care metrics for patient subpopulations is not sufficient to catalyze meaningful, actionable change. Critical next steps for the dashboard include further investigating the root causes of disparate outcomes and identifying targeted

interventions for this context while considering options that may also work at scale.²⁸ Ultimately, characterizing and tracking these variables may help close care gaps and allow for the provision of more equitable care.

AUTHOR CONTRIBUTIONS

Sojung Yi and Christopher R. Peabody conceived the dashboard design. Steven Straube and Joseph Graterol contributed to further development of the dashboard. Christopher R. Peabody supervised data collection. Caroline Burke, Amanda Reilly, Steven Straube, and Joseph Graterol managed the data and provided statistical analysis. Sojung Yi drafted the manuscript, and all authors contributed substantially to its revision. Christopher R. Peabody takes responsibility for the paper as a whole.

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CONFLICTS OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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