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Advancing Meaningful Use: Simplifying Complex Clinical Metrics Through Visual Representation

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INTRODUCTION As health care reform sweeps the country, more and more provider sites are integrating Electronic Medical Records (EMR) into their practice. In addition to providing health care professionals with access to data they have traditionally managed in a paper file —lab results, visit notes, diagnostic test results, payer information, demographics, health histories, prescriptions, etc.—EMRs offer enhanced features, such as data exchange between professionals, report generation, and population lists specific to a particular disease or medication.[1] Ideally, EMRs provide complete, accurate, and timely data, along with access to evidence based medical knowledge so that the quality of healthcare can be dramatically improved."[2]

Practitioners claim, "in order for EMRs to succeed, it is imperative that users be able to easily and accurately retrieve, seek, gather, encode, transform, organize, and manipulate pertinent information to accomplish desired tasks."[3] Yet, despite this ideal theoretical goal, in practice, EMRs often fail to achieve heightened usability because critical medical data is not displayed logically or in a way that accommodates clinical decision making. Furthermore, EMRs contain valuable data to drive effective practice management; however, the data are not readily available to practice managers and administrators either. Thus, both practitioners and managers would benefit from better access to the rich data contained in EMRs.

An August 2010 report issued by Healthcare Information and Management Systems Society (HIMSS) on selecting an EMR asserts the thoughtful *use of visual elements* can be a supporting factor that helps enhance product usability.[4] Edward Tufte, an authority on the visual display of data, suggests that graphical displays should accomplish more than just showing the data.[5] Effective design, according to Tufte, encourages the user to think about the substance of what is displayed by avoiding data distortion, presenting many numbers in a small space, making large data sets coherent, and encouraging the eye to compare different pieces of data.

Effective visualization therefore reveals the meaning of data at several levels of detail, from a broad overview to the fine structure. Undoubtedly, EMR users will have a better understanding of the data if they are able to coherently and comprehensively visualize the answers to critical clinical questions.

This paper will explore the ways in which EMRs can integrate best practices related to the visual display of data within a clinical environment. By first highlighting the important metrics used to measure the effectiveness of providers, and the care they provide to patients, design principles are presented that can heighten information visualization. Last, we will explore how using data visualization within a Patient Registry can impact quality healthcare.

IMPORTANT CLINICAL METRICS

Measures of clinical quality, patient experience, and efficiency provide a range of perspectives that reveal the extent to which particular providers or facilities are meeting state or national recognized standards of care. FIGURE 1 identifies standard quality metrics used by provider organizations in a range of settings, including inpatient, emergency department and ambulatory environments.

The Healthcare Effectiveness Data and Information Set (HEDIS) measures, for example, are used by more than 90% of America's health plans to measure provider performance on important dimensions of care and service. HEDIS has become a de facto standard for physician groups as well. Approved by the National Committee for Quality Assurance (NCQA), and covering a range of important health issues from asthma medication use to

CATEGORY	METRIC	ORGANIZATION	SETTING
Clinical Quality	Hospital Compare	CMS	Inpatient
	HEDIS	NCQA	Outpatient
Patient Experience	HCAHPS	CMS	Inpatient
	CAHPS	AHRQ	Outpatient
Efficiency or Cost	CMAD	Various	Inpatient/Outpatient

FIGURE 1: *Clinical Metrics for Various Settings*

comprehensive diabetes care, HEDIS measures are used for public reporting and physician incentive programs.

While HEDIS measures explore clinical quality in an outpatient setting, The Centers for Medicare and Medicaid Services (CMS) Hospital Compare provides information on 27 quality measures, which include clinical process of care and clinical outcome measures. These include mortality, infection and readmission rates. In addition, CMS's Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) is a standardized survey instrument and data collection methodology for measuring patients' perspectives of hospital care.

To measure the patient experience in outpatient settings, the U.S. Agency for HealthCare Research and Quality (AHRQ) utilizes Consumer Assessment of Healthcare Providers and Systems (CAHPS). This program offers several surveys and supplemental item sets that assess the experiences of health care consumers in various ambulatory settings, including health plans, managed behavioral healthcare organizations, dental plans, medical groups, physician offices, and clinics.

With the expanded focus on reducing rising health care costs, metrics are now exploring efficiency and cost effectiveness of care. On the inpatient side, measures typically used for this activity are Case Mix Adjusted cost per Discharge (CMAD) and cost per adjusted patient day. These measures rely on accurate risk adjustment (such as 3M's APR-DRGs). No risk adjuster is perfect; nonetheless, they serve as powerful tools to allow fair comparisons between institutions caring for different populations of patients.

Using CMAD, users can compare the cost of treating a particular condition at one hospital against another. For instance, one can compare the cost of heart attack care among hospitals within a city. Even if one of the hospitals tends to treat more complex heart attack patients, the risk adjustment software will factor this in and give case-mix and severity adjusted costs to enable a fair comparison.

The above mentioned clinical metrics are helpful in profiling hospitals, physician practices and/or individual practitioners. EMRs can enhance the performance of medical groups by using their data to guide both clinical and managerial decision making. Effective technology systems would enable a user to explore high-level data at the patient population level, and then drill down to the practitioner level or a particular patient. Accessing integrated lab results, diagnostic test results, payer information, patient demographics, health histories, and medication histories enables the user to determine contributing factors to clinical outcomes. It is challenging to obtain this data because it is often awkwardly stored in the EMR and difficult to retrieve. Further, most EMRs will only display the information on individual pages or, at best, in tabular form, which makes it difficult to grasp its significance. More effective EMR visualization, however, leads to easier interpretation of the data.

INFORMATION VISUALIZATION BEST PRACTICES

Indeed, EMRs are synthesizing large sets of complex data and must be designed with usability in mind. With consideration for the Graphic User Interface (GUI), best practices for the visual display of data include:[6]

- Visibility of the user's system status, keeping them informed about what is going on;
- Match between the system and the real world, including using language and concepts familiar to the user;
- User control and freedom to support undo's and redo's;
- Consistency and standards that considers user behavior, structures, and overall look;
- Error prevention that eliminates risky conditions or checks for them and presents user with a confirmation option;
- Recognition rather than recall to minimize the user's memory load by making objects, actions and options visible;
- Flexibility and efficiency of use with accelerators that allows users to tailor frequent actions;
- Aesthetic and minimalist design that excludes irrelevant or rarely needed information;
- Help and documentation that is easy to search, is focused on the user's task, and lists concrete steps to be carried out.

Additional principles for effective interactive design[7] include anticipation, in which applications attempt to anticipate the user's wants and needs, as well as autonomy, which recognizes that while the computer and task environment "belong" to the user, standard mechanisms and rules must be in place.

DISPLAYING CLINICAL INFORMATION

EMRs do not just capture critical clinical information. They can be used to display information in a way that is meaningful to individual clinicians/users and facility administrators. As individual health records generally share a common structure, different display tools can be used to describe populations, trends and comparisons utilizing the same health data that describes individual patients. As such, meaningful clinical information representation can occur at the individual and group level and ultimately provide a wide-ranging view of the health spectrum.

Currently, most EMRs have weak or nonexistent display capabilities and thus do not provide meaningful knowledge to their users. This is a result of EMR designers focusing on replicating historical methods of data capture into the electronic medium.[8] However, this does not necessarily leverage the underlying capabilities of the health information itself: for example, by replicating paper records one finds difficulty accessing longitudinal health information or understanding commonalities among patients with similar health concerns.

Ultimately, without utilizing design best practices and leveraging techniques to better visualize patient information, clinical data will be poorly displayed and create several problems: confusion in correctly understanding the information, inability to access and navigate the information, support incorrect diagnosis, inability to identify larger health issues and trends, etc.

The following figures are examples using advanced visualization concepts and geared for integration within an EMR GUI. These PIIM-developed visualizations demonstrate enriched features and reporting not available when just using table/spreadsheet type views common in most current EMRs.

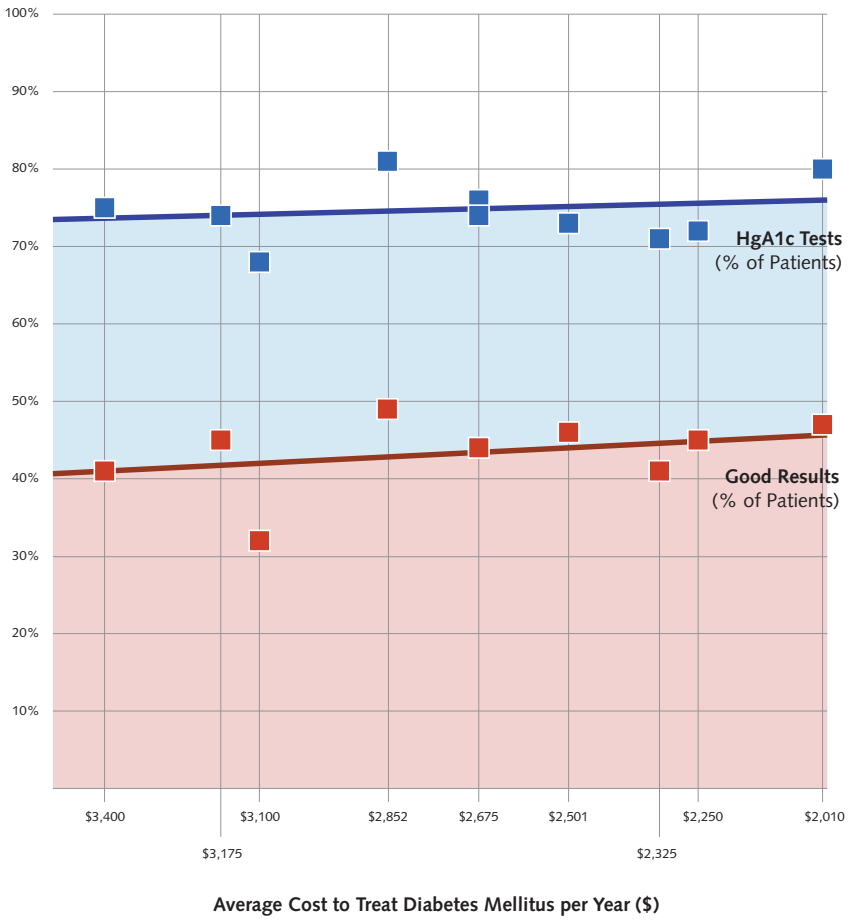

FIGURE 2: *Using CMAD measures, users can compare episode cost of treating a particular condition at one hospital against another. For instance, one can compare the cost of heart attack care among hospitals within a city. However, through informative visualization one can also leverage CMAD data to inform health care provider and patient practices. As an example, this graphic explores the cost effectiveness of HgA1c testing.*

CMAD data from multiple health care providers was plotted on a Cartesian plane. The x-axis measures the average cost to treat Diabetes Mellitus in a single patient per year; the y-axis measures both the percentage of patients who undergo HgA1c testing twice a year and the percentage of patient who have good HgA1c testing results. The scatter plot of blue and red square nodes represent CMAD data points; the blue and red lines are trendlines for their corresponding nodes.

The scatter plot shows a correlation between increased patient testing, better control of patient blood sugar, and a reduced average cost of treating Diabetes Mellitus per year. In contrast, tables offer no more insight than the data points themselves.

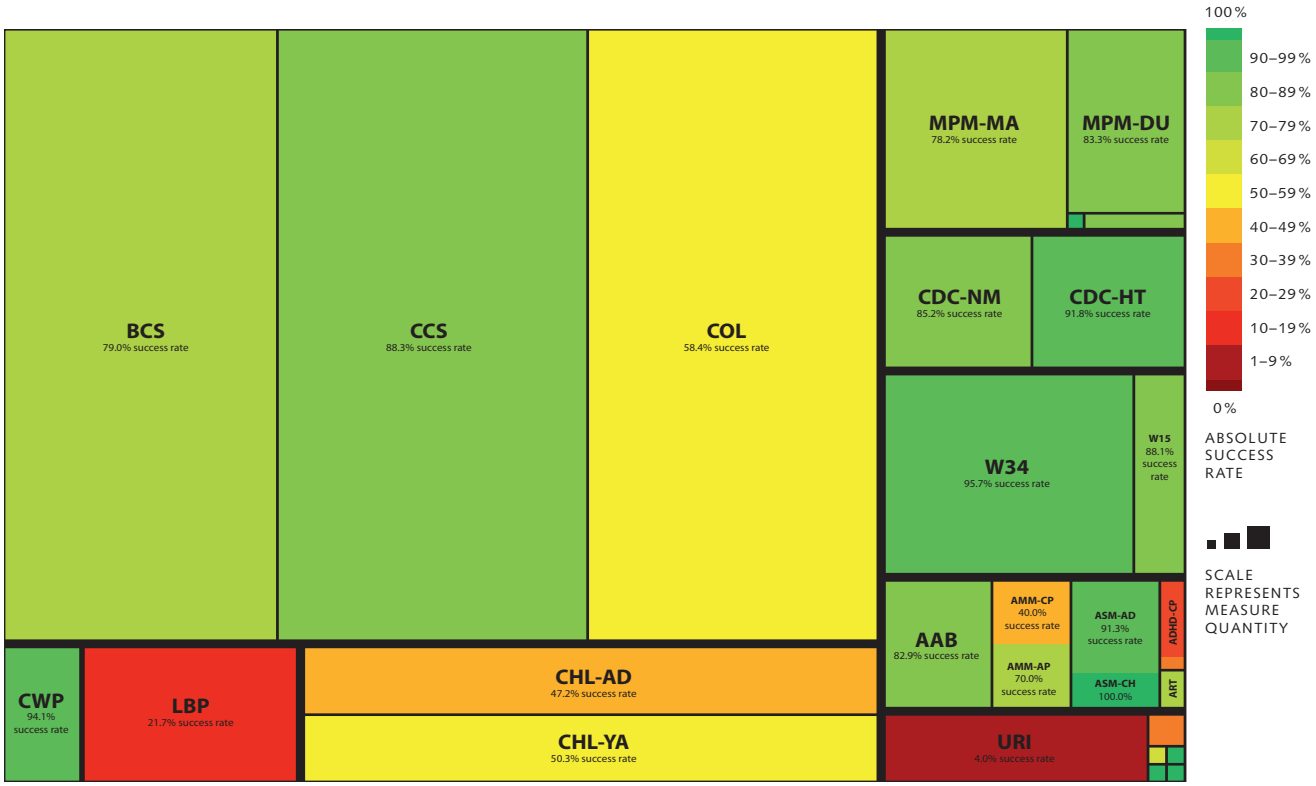

FIGURE 3: *The Healthcare Effectiveness Data and Information Set (HEDIS) measures performance of clinical care and service. The above visualization illustrates a single health care group's HEDIS measurement scores with color representing success rate and scale representing the quantity of occurrence. Related HEDIS measurements are grouped together (e.g., proper use of cancer screening: BCS, CCS, and COL).*

Because each HEDIS measure is composed of different numbers of eligible (or applicable) patients, tabular formats visually distort the relative importance of individual measures. This distortion occurs because tables and lists represent multivariate measures through text alone, giving each element the same visual weight. The reader explores values linearly and must infer the relationship between the values within a single HEDIS measure and between multiple HEDIS measures.

Alternatively, informative visualization allows the reader to visually experience these relationships simultaneously and instantaneously. The reader has no need to actively weigh success rate against measure quantity for multiple measurements to determine the relative severity of a problem area. Instead, these relationships are immediately apparent through visual comparison.

For example, the success rate for both the LBP and the ADHD-CP measures are both in the 20–30% range, as indicated by their bright red color in the visualization above. However, the ADHD-CP's extremely low success rate is counterbalanced by it's relatively small size, representing the measure's lower rate of occurrence. It is immediately apparent that although the success rates of LBP and ADHD-CP are comparable, the effects of the deficiency are not.

Utilizing informative visualization in this example, the interaction of color and scale provides the reader with an immediate sense of where efforts to improve quality and correct deficiencies would be best spent.

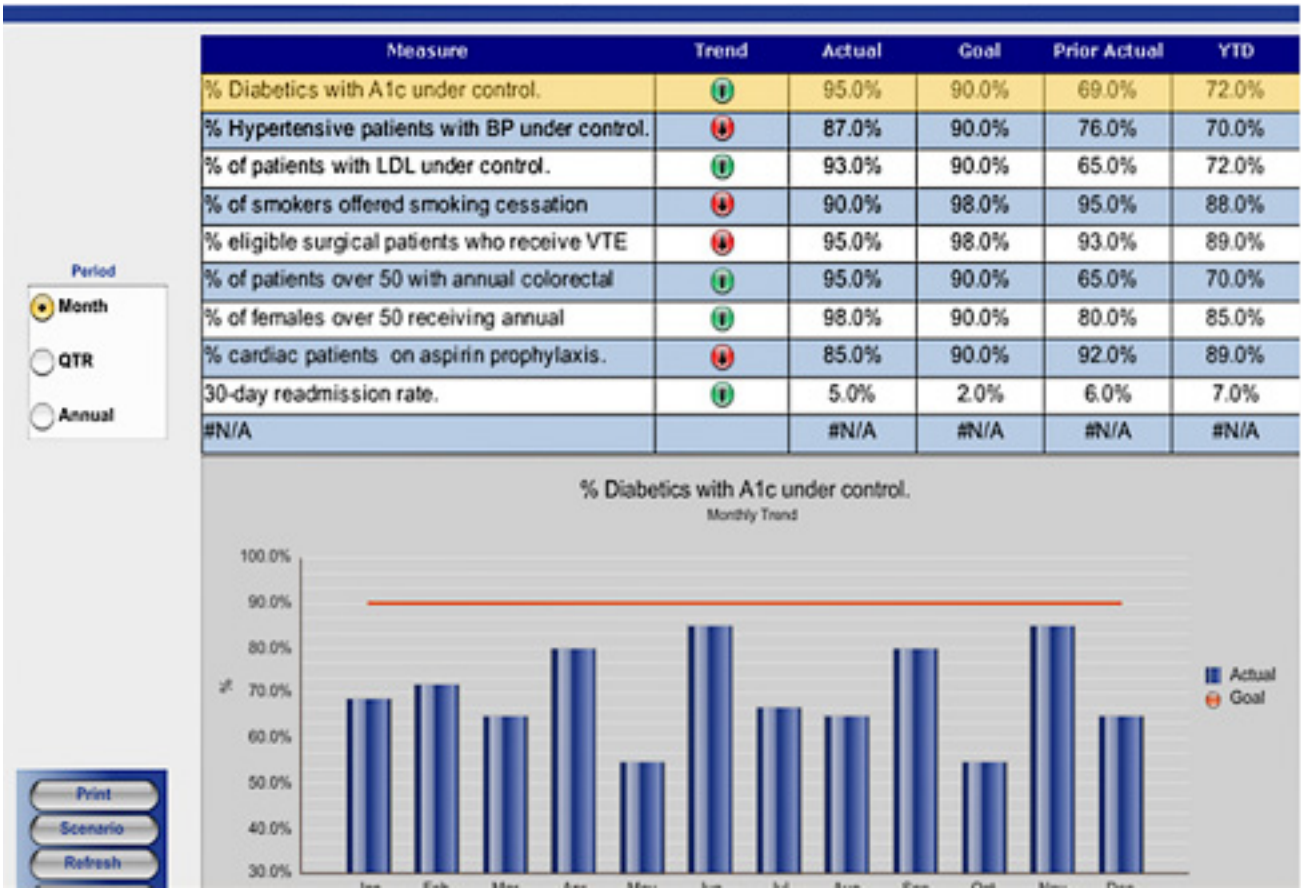

FIGURE 4: *A similar set of data as in FIGURE 3 (previous page) is presented within a standard EMR GUI. The table portion of the above screen distorts the relative importance of measures by failing to indicate relative scale.*

The treemap presented in FIGURE 3 would be a major improvement over the table format above. However, the treemap should be tailored to fit the idiosyncrasies of this unique use-case. This could be accomplished by tweaking the color scale: Instead of indicating absolute percentage scores, a similar color system could be used to indicate scores relative to "goals" (with shades of red indicating those scores falling below their goals, and shades of green indicating those scores meeting or exceeding their goals). The trend icons would function equally well in the treemap environment.

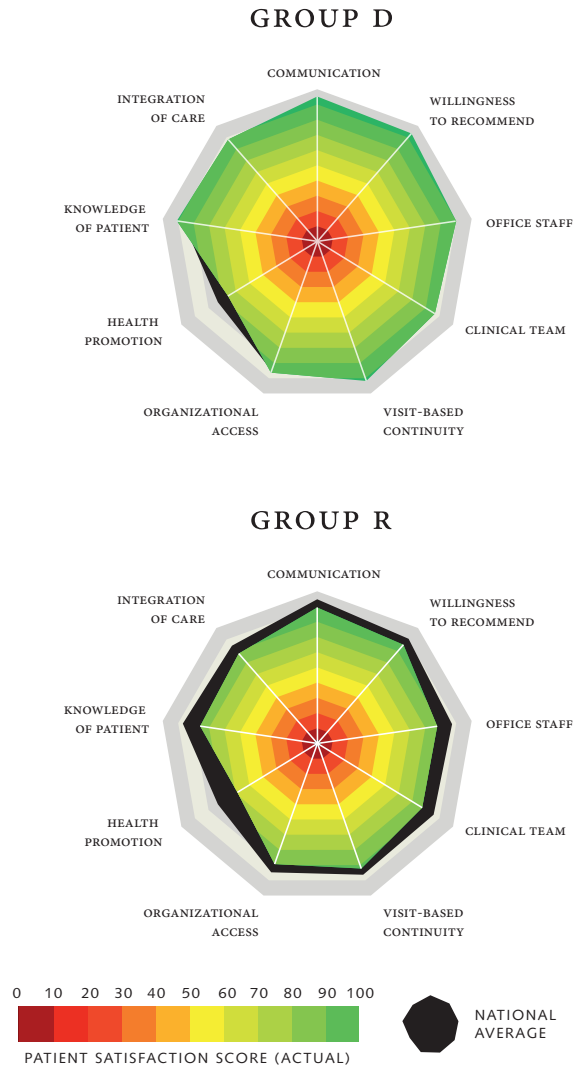

FIGURE 5: *CMS's Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) is a standardized survey instrument and data collection methodology for measuring patients' perspectives of hospital care.*

Unlike HEDIS measures, each HCAHPS measurement occurs in roughly the same quantity. As such, a new visualization strategy is needed. Utilizing radial graphs (like the HEDIS treemap visualization presented in FIGURE 3) one can rapidly access and compare strengths and weaknesses of similar items—in this case, patient groups. One advantage of using radial graphs is the ability to compare between multiple groups and against the national average. In these visualizations it is easy to identify the better-performing group and understand its position relative to the national average in a single visual.

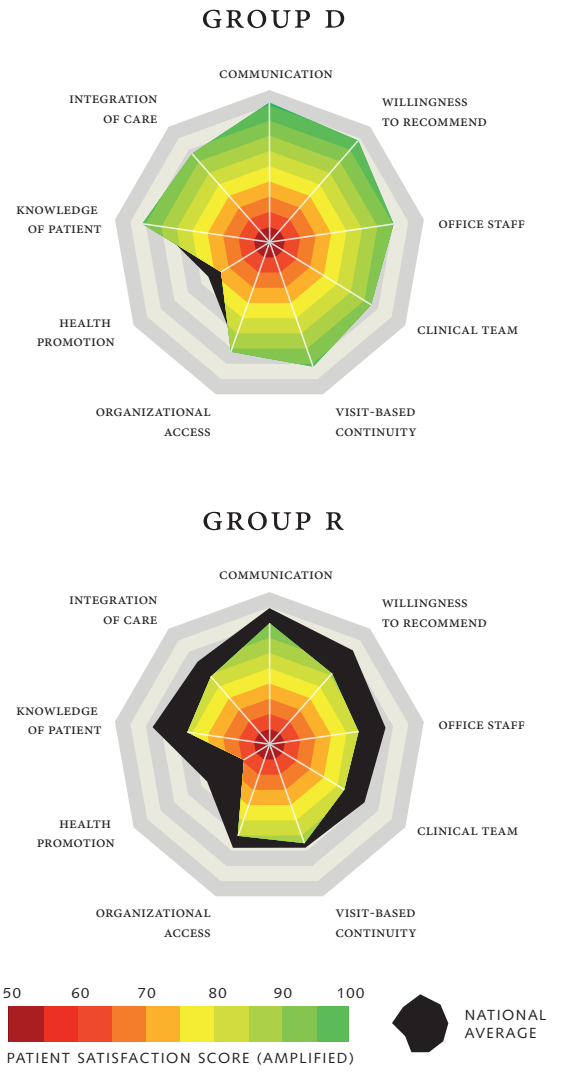

FIGURE 6: *When using absolute scales, the differences in scores between groups may be too subtle to be easily detected by the reader. In cases such as these altering the scale with the intent of illuminating differences, known as amplifying, is oftentimes appropriate.*

The three radial graphs to the left illustrate the same data contained in FIGURE 5, but with the patient satisfaction score range narrowed from 0–100 to 50–100 (see revised legend). Although amplification removes some contextual value, it does not change the conclusions drawn from the data: Group D performs better than Group R.

Integrating these visualizations into an EMR GUI where a clinician or user can adjust the ranges (e.g. amplification) will provide much greater comprehension and analysis of the underlying clinical metrics.

EFFECTIVE EMRS AT WORK: PATIENT REGISTRIES

As you can see from the examples above, understanding how to choose the best visualization and being able to produce it in the most user-friendly manner should be a critical competency of an EMR. Doing so enables clinicians, facility managers, and users to clearly and effectively comprehend complex clinical information. Within an EMR GUI, visualizations like the ones presented in this paper can improve the efficiency of a practice and support its efforts at quality, patient experience, and cost containment.

The examples presented in this paper were developed using actual clinical data and geared towards depicting potential visualizations to support a patient registry with a focus on diabetic patients. Patient registries are a core function of any EMR and provide an organized listing of all patients with a particular condition that need ongoing care. Registries store all relevant clinical information needed to provide excellent care to those patients and in this example—a diabetes registry—several key sets of information are stored: patient information (name and contact information), key clinical variables (medications and dosages, results of recent laboratory tests, and consultations with specialists), along with a listing of required routine services (annual flu shot, eye examination, HgA1c testing, etc.). A typical patient registry combines this information in a single location allowing a clinician or practice to easily make changes to a patient's care and to support ongoing care.

The data contained in a patient registry and the associated activities surrounding input and output of that data (e.g. the human interactions between clinician/practice and the patient) provide a unique crossroads of information related to HEDIS (clinical performance) and HCAHPS (patient experience) information. Assessing these measurements using traditional display/representation methods inadequately represents the breadth and complexity of the data itself. And, without leveraging visualization capabilities—and by just providing text-heavy information—clinicians may struggle to comprehend the intricacies of the data and make informed decisions within their already hectic schedules.

For example, as identified in FIGURE 5, it would be very difficult to understand Group D's relationship to the national average across the nine dimensions through tabular data. It would also be difficult to highlight the single metric (e.g. Health Promotion) in which Group D falls short of the national average. These difficulties are compounded when one must make a comparative analysis of numerous patient groups. However, the examples provided in this paper demonstrate a clear and efficient method to visualize this information in a way that is both intuitive and easy-to-understand: for example, by color-coding satisfaction results one can instantly see where a patient group is signaling an area of concern.

EMRS identify patients for a registry from either a patient's problem list or the diagnoses listed by their treating physicians. Registries can be created for as many conditions as desired and diabetes, hypertension, heart failure, long-term anticoagulation, and asthma are very common. A practice will create a handful (or more) registries to help manage high-risk patients with chronic conditions. Ultimately, the ability to analyze and report on the registries becomes more difficult as the number of registries and the number of patients in each registry grows.

By leveraging informative visualization within an EMR to generate additional meaningful use, practices can more successfully find patients who are overdue for an appointment or routine test, ensure follow-ups occur, identify tests that have been ordered but not yet received, and most importantly, make certain that patients receive timely care. As shown in the examples in this paper, using visualization strategies within a patient registry can ensure better outcomes for the patient, reduce the risk of complications, and support a more efficient practice.

CONCLUSION

An EMR is the "face" of a rich database of vital clinical information. We have described how effective visual display of clinical data is an important component of an effective EMR. Good information design and visualization support more effective and efficient health care.

As important as visualization is to an EMR, good practice in visualization is becoming wide spread as the range of clinical information tools expands. With the increased use of personal health records such as Google Health and Microsoft's HealthVault, users will become aware of the importance accessing information in an easily understandable way. Expert data design and visualization will enhance clinical software tools and help practices achieve success in the changing health care landscape under reform.

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NOTES

1 American Medical Association website, http://www.ama-assn.org/ama/pub/physician-resources/solutions-managing-your-practice/health-information-technology/putting-hit-practice/understanding-hit-applications.shtml.

2 J. Cimino, J. Teich, V. Patel, and J. Zhang, "What Is Wrong with EMR," Panel proposal submitted to AMIA '99 Program Committee.

3 Ibid.

4 HIMSS EHR Usability Task Force,"Selecting an EMR for Your Practice: Evaluating Usability, V1.1," (Healthcare Information and Management Systems Society, August 2010).

5 Edward Tufte, *The Visual Display of Quantitative Information*, 2nd ed. (Cheshire, CT: Graphics Press, 2001).

6 Jakob Nielson, "Ten Usability Heuristics," http://www.useit.com/papers/heuristic/heuristic_list.html.

7 "First Principles of Interaction Design," AskTog. www.asktog.com/basics/firstPrinciples.html

8 William Bevington and David Fusilier, "Health Care Service Iconography: Enhancing Medical Record Lucidity Through Intelligent Iconography," *The Parsons Journal for Information Mappin*g 2, no. 2 (Spring 2010): 6–8.