Health Information Technology Department
Mashhad University of Medical Sciences

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Improving the Efficiency and Ease of Healthcare Analysis Through Use of Data Visualization Dashboards

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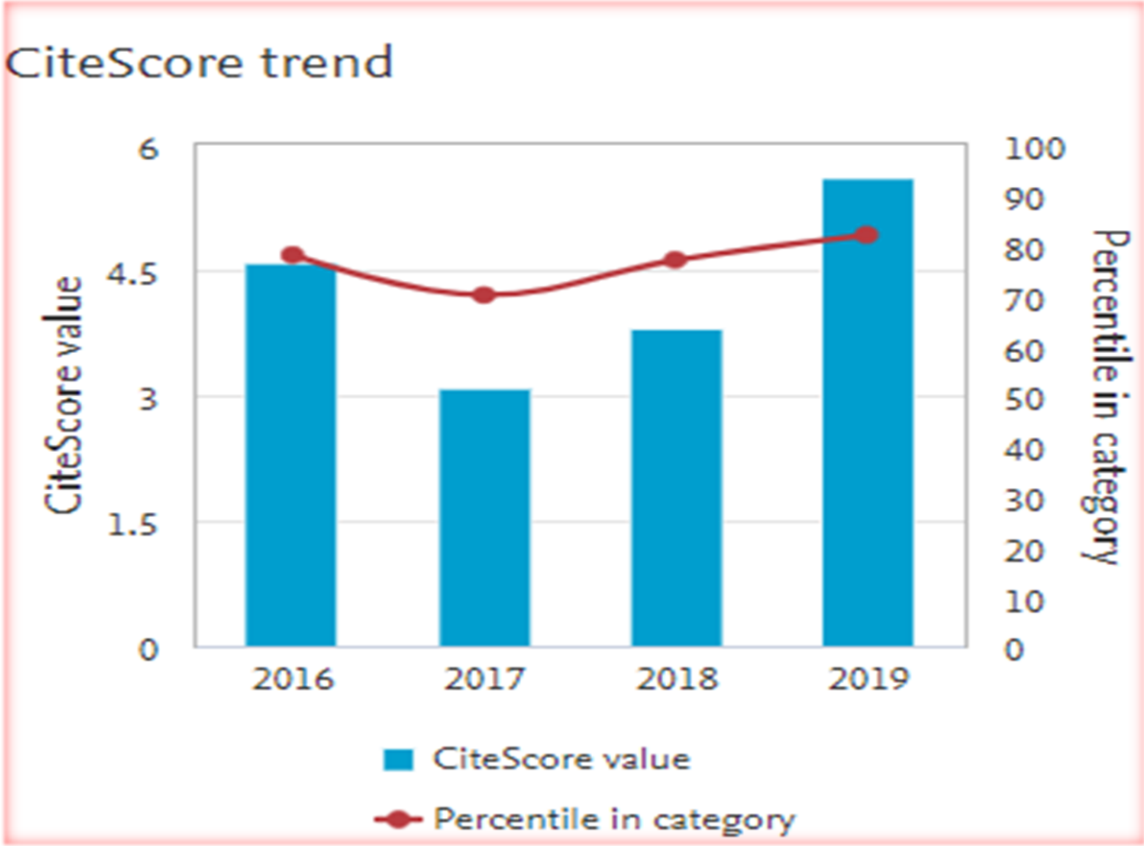

The digitization of a patient's health record has profoundly impacted medicine and healthcare.Spanning the range of a patient's encounter (vitals,labs, diagnoses, procedures, medications, etc.), while also providing historical context (medical, family, and social history), data contained within the EHR can paint a robust picture of a single visit, or longitudinal medical history. Further, the ability exists to zoom out and view higher-level summaries of a patient population (specific condition or procedure group), unit (medical floor, ICU), facility, or entire health system.

The potential impact of the data is exceptional. Studied and applied appropriately, it can be transformative–guiding quality improvement, establishing best practice standards, and identifying opportunities for improvement.

As stated by Murdoch and Detsky :

"The first information technology revolution in medicine was the digitization of the medical record. The second is surely to leverage the information contained there in and combine it with other sources. **Big data** has the potential to transform medical practice by using information generated every day to improve the quality and efficiency of care."

The abundance of data can be overwhelming. Utility is easily masked by the noise of numbers, and the time required to mine for value can be prohibitive. Further, although long-term analysis is important, use of EHR data for daily analysis is critical.

The clinician’s immediate concern is often current performance, and how that compares with the previous week or month, and not the big analytics picture. This concern is well founded, as daily clinical processes determine the success or failure of improvement initiatives.

Removal of the limitation of being bound by a particular facility or system opens another avenue of crossfacility data exploration and allows the use of trends comparatively, adding an industry-wide context to any analysis or findings.

Humans have a limited capacity to process information, and without proper tools, as complexity increases, accuracy of interpretation decreases. The amount of data contained within the EHR raises the possibility of overlooking or misinterpreting the value within the data. One powerful option by which complex data could be made accessible, consumable, and meaningful is through the **use of interactive visualizations**

The goal is to produce easily understood visuals to aid the users' ability to quickly and accurately process information so that conclusions can be **drawn**, **decisions made**, and **actions taken**. Although the popularity of dashboards as analytic tools is growing, their use with EHR data is still in its infancy. Certainly, some healthcare organizations utilize EHR data, along with other sources, in dashboards to monitor performance at the individual facility or system level. Few studies exist, however, detailing the creation, use, and benefits of EHR data visualizations.

One possible explanation could simply be the immense volume of data within the EHR. Summarizing all the important information, even visually, is impossible; therefore, decisions about priority of information must be made.

Two common concerns for health systems are early identification and treatment of sepsis, and prevention of 30-day hospital readmissions. Sepsis is a systemic inflammatory response to infection, which can progress to severe sepsis (sepsis with organ dysfunction) or septic shock (severe sepsis plus hypotension that persists after fluid resuscitation). Sepsis incidence is on the rise, and detection, while improving, remains challenging.

Further, sepsis is an incredibly costly disease. From the patient side, mortality rates for severe sepsis and septic shock range from 20% to 50%, and survivors often experience a decreased quality of life. On the caregiver side, sepsis can account for up to 50% of all hospital deaths and is the most expensive condition treated in U.S. hospitals.

Similar to sepsis, 30-day hospital readmissions are a measure reported to CMS. Hospitals with excessive readmission rates for select conditions/procedures face penalties.

In response, many hospitals have developed readmission prevention programs, dedicating resources to improving discharge processes.

The goal is to use these dashboards for data monitoring and analysis of hospitals both individually and as a group. Although the decisions produced by an analysis will vary by each healthcare facility's specific circumstances and environment, **common goals** include identifying quality improvement, progress in patient outcomes, and the need for further optimization.

Thus, we compare time spent building, maintaining, and using these dashboards with the time required for the traditional manual data analysis to assess the impact of the visualization tools.

Dashboard design

Dashboard development and maintenance

Efficiency and time savings calculations

Dashboard design

The designs of the dashboards need to accomplish three broad goals:

1. increasing efficiency while decreasing variability of the analysis process,
2. meeting the needs of the analytics team (analysts, data scientists) while being accessible to a range of diverse users (clinical,administration, IT, business, etc.),
3. **accommodating any hospital's EHR data.**

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Dashboard design

Select Dashboard

Although the ultimate goal is to have a dashboard for a variety of CDS systems, sepsis and readmission prevention were chosen first. This decision was based on the level of burden to health systems, complexity and time of analysis, and requests from potential dashboard users.

Dashboard design → Select key indicators

Working with project leaders and consultants, and drawing from previous analyses, we identified the most valuable metrics to evaluate outcomes and processes related to sepsis and readmission prevention.

For sepsis, these measures included sepsis incidence, length of stay, and mortality rate.

For readmissions, we developed process metrics related to the CDS system , which were risk stratifications of the target population, plans of care initiated, and follow-up appointments scheduled. These key indicators were defined in requirements documents.

Dashboard design

Identify the Best types of visualizations

User input helped identify what types of visualizations would be the most meaningful. We created several visual representations of each metric, aiming at displaying the information in one to two views to minimize navigation and clicks. Further, metrics were visualized across the months for which historical data were available, as identifying trends and anomalies in data are important to end-users. Multiple versions of the dashboards were developed, tested, and revised before release to a select number of consultants.

Before the advent of dashboards

Before these dashboards, the analytics teams manually queried, cleaned, aggregated, and analyzed data one facility at a time. An analyst accessed and extracted readmissions or sepsis data in 1-month increments. Data were then aggregated and cleaned in R before exporting to an Excel workbook where pivot tables and graphs were created to calculate and visualize each metric.

By standardizing the analysis, variability in metric definition and user errors during data aggregation and cleaning are eliminated.

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Dashboard development and maintenance

In contrast to manual extractions from individual facilities , the dashboards utilize Tableau visualization software and aggregated hospital-level data from a cloud platform. Once education from the database architects on the existing summary tables was complete, the team began extracting data and continues to do so on a monthly basis. Extractions rely on SQL queries, and the resulting data are then formatted into comma separated values that can be consumed by Tableau.

Dashboard development and maintenance

Dashboards are maintained through an automated process. The team executes the SQL query monthly , pulling data across facilities, and these data are added to a master file connected to Tableau. The extracts in Tableau are refreshed, and data of all facilities are updated and available to end-users. When new facilities implement the CDS systems, data are automatically added to the cloud tables and the monthly data extraction. The views are housed in an internal server that associates various roles that one can have access to.

Efficiency and time savings calculations

To estimate time savings, we calculated the average amount of time spent on manual analyses of sepsis and readmissions and determined how many clients are included in the two dashboards. We gauged how many clients are analyzed annually and multiplied that number of clients by the number of hours allotted for the analyses. From this value, we subtracted the number of hours that the team spends on dashboard development and maintenance and the time spent on review and interpretation with project teams. We calculated time savings for year 1, when the dashboards were developed, and projected time savings for years 2 and 3.

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Efficiency and time savings calculations

Annually, the analytics team is responsible for analyzing the data of ~40% of all sepsis clients and ~65% of all readmissions clients. Analysis rates were calculated from data analysis tracking records, which have been maintained during the last 6 months of 2015.

The following formula was utilized to determine time savings:

Total Hours Saved =

((Total Number of Clients * Rate of Clients Analyzed) * Average Manual Analysis Hours per Client) - (Development and Maintenance + Review and Interpration))

Efficiency and time savings calculations

Finally, we utilized a two-sample t-test to determine any statistically significant differences between the time spent per client project on manual analysis and the automated process via the two dashboards. We calculated the average amount of time to conduct a manual analysis using internal tracking data on manual analyses completed in 2015. To calculate the average time spent per project in the new method, for each dashboard, we divided the number of hours used for dashboard development and maintenance by the number of clients analyzed annually.

Development and utilization of these dashboards has resulted in significant time savings. What was previously manual, completed on an *ad hoc* basis for one client at a time, has now been converted into a central resource where analysis of many clients' data is readily available to end-users.

For sepsis outcomes, this work required one analyst to spend ~5 hours gathering and analyzing data from one average-sized client, plus around 1 hour **reviewing** results with the project team. For readmissions outcomes, this work required ~4 hours, including 3 hours of analysis and 1 hour of review.

Using the manual process, the analytics teams spent ~446 hours analyzing sepsis outcomes across clients in year 1 (74 clients multiplied by 6 hours). After subtracting the hours for dashboard development and maintenance (37 hours in year 1) and reviewing the dashboard internally (120 hours annually), ~289 hours were saved in year 1 (Table 1). We project that in years 2 and 3, we will save ~326 and 350 hours, respectively. When compared with the manual sepsis analysis process, the time spent per client project has been reduced significantly, t(73) = 4.97, **$p < 0.001$.**

Table 1. Time savings calculations from sepsis dashboard development

	Year 1	Year 2	Year 3
Sepsis dashboard			
Number of clients in dashboard	186	196	206
Clients analyzed on annual basis (40%)	74	78	82
Average hours per client—manual process	6	6	6
Manual analysis—total hours	446	470	494
Dashboard development and maintenance	(37)	(24)	(24)
Project team review of dashboard and interpretation	(120)	(120)	(120)
Total time savings (in hours)	289	326	350

Table 2. Time savings calculations from readmissions dashboard development

	Year 1	*Year 2*	*Year 3*
Readmissions dashboard			
Number of clients in dashboard	18	42	66
Clients analyzed on annual basis (65%)	12	27	43
Average hours per client—manual process	4	4	4
Manual analysis—total hours	47	109	172
Dashboard development and maintenance	(30)	(24)	(24)
Project team review of dashboard and interpretation	(48)	(48)	(48)
Total time savings (in hours)	0	37	100

Utilization of data visualizations has resulted in significant time savings for the analytics team. Between the two dashboards, we estimate a total of 289 hours saved in year 1, and project savings of ~364 hours in year 2 and 450 hours in year 3. Assuming a 40 hour work week, these time savings translate to approximately **seven full weeks of work** in year 1, 9 weeks in year 2, and 11 weeks in year 3 (Table 3).

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Table 3. Cumulative time savings from development of sepsis and readmissions dashboards

	Year 1	*Year 2*	*Year 3*
Total time savings			
Total time savings—Sepsis dashboard	289	326	350
Total time savings—Readmissions dashboard	0	37	100
Cumulative hours saved	289	364	450
Cumulative weeks of work saved[a]	7	9	11

[a]Assumes a 40-hour workweek.

This work demonstrates that interactive data visualizations can optimize data analysis in healthcare IT. The dashboards described have almost completely eliminated the need for time-consuming manual analyses of sepsis and readmissions data.

The dashboards have enabled a broader range of end-users to access data and gather insights.

Although similar EHR dashboards exist at individual healthcare facilities, important differences set apart the work described here. Though helpful, localized efforts produce disparate visualizations that are unique to the institutions that created them.

This makes comparisons difficult and limits the scope of analysis.

These dashboards have accomplished the goals of increasing the speed and consistency of analysis, but the work described here is evaluating only part of the process.

The aim was not to change the conclusions reached and decisions produced from the analysis.

More work is needed to fully understand the impact of dashboards on decisions made based on the data.

The lessons learned and benefits from these visualizations can now be translated across other areas of healthcare and technology.

Data cleaning and aggregation across many facilities posed significant challenges in this process. The finished product, however, outweighed these challenges, as we were able to leverage the data easily for visualizations and utilize similar data structures for other projects.

Additionally, project teams and key stakeholders needed requisite education on utilizing these two dashboards, and appropriate collateral and documentation still require improvement as the dashboards are released to more users.

More development and research on the benefits of data visualization in healthcare is needed , but our efforts illustrate that substantial time savings are possible and the world of data analysis can be opened to many roles outside of analytics teams.

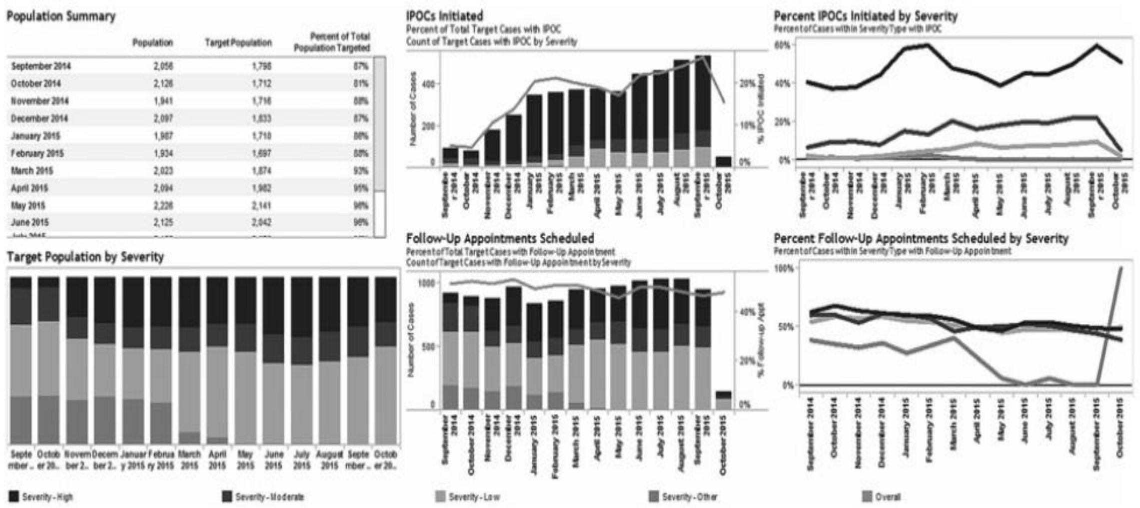

FIG. 2. This 30-day readmissions dashboard gives users the ability to view summaries and trends in their clients' populations. Combinations of column and line charts display the percentages of interdisciplinary plans of care and follow-up appointments scheduled in comparison to the number of readmissions cases, each broken down by predicted risk severity.

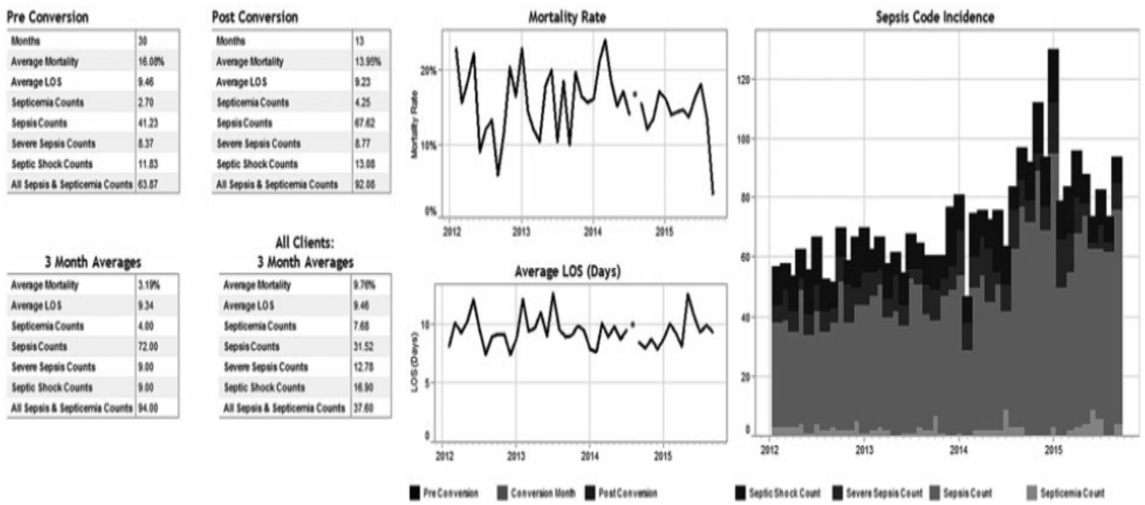

FIG. 1. This sepsis outcomes dashboard gives users a concise view of the clients' key performance indicators. The dashboard shows mortality rate, length of stay, and sepsis coding by month, along with a 3-month rolling average across all clients in the dashboard.

Thanks for Your Attention

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