

Visualization of Order Set Creation and Usage Patterns in Early Implementation Phases of an Electronic Health Record

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Abstract

Robust order set catalogs are considered to be a vital part of a computerized physician order entry (CPOE) implementation. Tools and processes for building, localizing, and maintaining these content sets in a centralized repository are important in facilitating the knowledge management lifecycle. Collectively, these order sets represent a significant investment of effort and expertise in capturing and distributing best clinical practice throughout an enterprise. In order to address an important gap of understanding how order sets are both created and used in practice in a current EHR installation, we have developed tools to analyze how order sets are used and customized in clinical practice. In this paper, we present the capabilities of these tools. We further characterize early development patterns in our enterprise order set catalog in early phases of a system-wide vendor EHR rollout. We present data that show how personalized order sets (favorites) are authored and then used in clinical practice. We anticipate that this type of utility will provide useful insight and feedback for those tasked with content governance and maintenance in CPOE systems.

Introduction

Computerized physician order entry (CPOE) systems pose an interesting challenge in clinical knowledge management. Order sets, or standardized groupings of orders targeted to specific clinical conditions or scenarios, have been shown as an important part of user acceptance of CPOE. When physicians use order set templates, they often find personal benefit from the convenience of large groups of clinically-relevant orders being readily available for selection and customization. Organizations can also find benefit, often using order sets as a vehicle to drive standardization processes and reduce unnecessary variation in clinical care.

While electronic health record vendors provide tools and infrastructure for supporting computerized ordering processes, the population of knowledge in the form of order sets is often left to the institution itself. Typical implementations often involve a significant effort or investment in building (or purchasing), refining, localizing, and maintaining order set catalogs^{1,2}. These content libraries are designed to support routine procedures and common conditions treated by care teams in clinical domains³. Previous research⁴⁻⁹ has detailed many of the challenges associated with knowledge maintenance in order set catalogs, including:

- Lack of personnel and resources to build order set libraries at the enterprise level
- Immature and poorly-adopted standards for order sets and orderable catalogs impede the effective sharing of order sets from one institution to the next
- Building and maintaining order set catalogs requires a sizable investment in time and resources
- Implementations often suffer lower uptake of order sets within CPOE due to gaps in content coverage in order sets libraries
- Conversion of purchased libraries to local practice requires refinement
- Clinical knowledge advances rapidly and the need to update and maintain content within order sets is constant

The various phases of the knowledge management lifecycle are depicted in Figure 1. In preparation for an enterprise installation of a new EHR and CPOE system, we identified that visibility in order set authoring and usage data would be a key gap in our knowledge management processes¹⁰. Content authors were quick to indicate their desire for systems that present utilization data as feedback to assist in refining their order sets. Previous research has shown that automated processes for summarizing utilization data can be turned into reporting feedback loops that facilitate content change¹¹⁻¹³.

Background

Intermountain Healthcare¹⁴ is a not-for-profit integrated healthcare delivery system based in Salt Lake City, Utah. It provides healthcare for the residents of the Intermountain West, including the entire state of Utah and parts of southern Idaho. Intermountain maintains a health insurance plan, 22 inpatient hospitals (including a children's hospital, an obstetrical facility and a dedicated orthopedic hospital), more than 185 outpatient clinics, and 18 community clinics serving uninsured and low-income patients. Collectively, it provides primary and specialty care for nearly half of the residents of the state of Utah. Informatics teams provide support to clinical users in the form of clinical decision support, clinical knowledge management, content maintenance and software development for unmet clinical needs.

In late 2013, Intermountain Healthcare and Cerner Corporation announced a strategic partnership, including an enterprise rollout of the Cerner EHR platform, and a joint development effort aimed at delivering novel informatics solutions for healthcare organizations. Implementation of the system is still underway, with several sites in the enterprise currently live on the new software. One of the strategic priorities of Intermountain's Cerner installation focuses on implementing and measuring utilization patterns of best practice care process modules into the system, in the form of order sets, decision support rules and care pathways. In order to address the need of understanding and reporting how knowledge content input into the system is actually being used we set about to build an interactive dashboard that illustrates the usage of order sets, personalized order sets derived from them (hereafter referred to as 'favorites') and how collective differences in the composition of favorites, in concert with utilization data can drive suggestions for optimizing order sets.



Figure 1- Knowledge Management Lifecycle. In this cycle, content is created, distributed, and used within a clinical system. Detailed usage data is captured, transformed into specific feedback, and provided back to content owners to facilitate further refinement.

Methods

Working with technical staff and data analysts, we extracted data from relevant tables in our production Cerner Millennium database environment and moved the data to Intermountain's data warehouse. For the purposes of development, approximately 12 months of usage data were extracted (February 2015 to February 2016). This resulted in data derived from nearly 300,000 order set usage instances. Filtering this data to exclude data derived from technical staff and/or testing data reduced the data set by approximately 20%.

Following several sessions with clinical sponsors focused on design and requirements definition, we used Tableau software to prepare an interactive dashboard that presents visual depictions of order set usage. Figure 2 shows the main view from this dashboard, in which all order sets in the catalog are visible, ranked by overall usage, with two

main color depictions illustrating overall ordering volumes from the standard template, as well as the collective favorites that were derived from it.

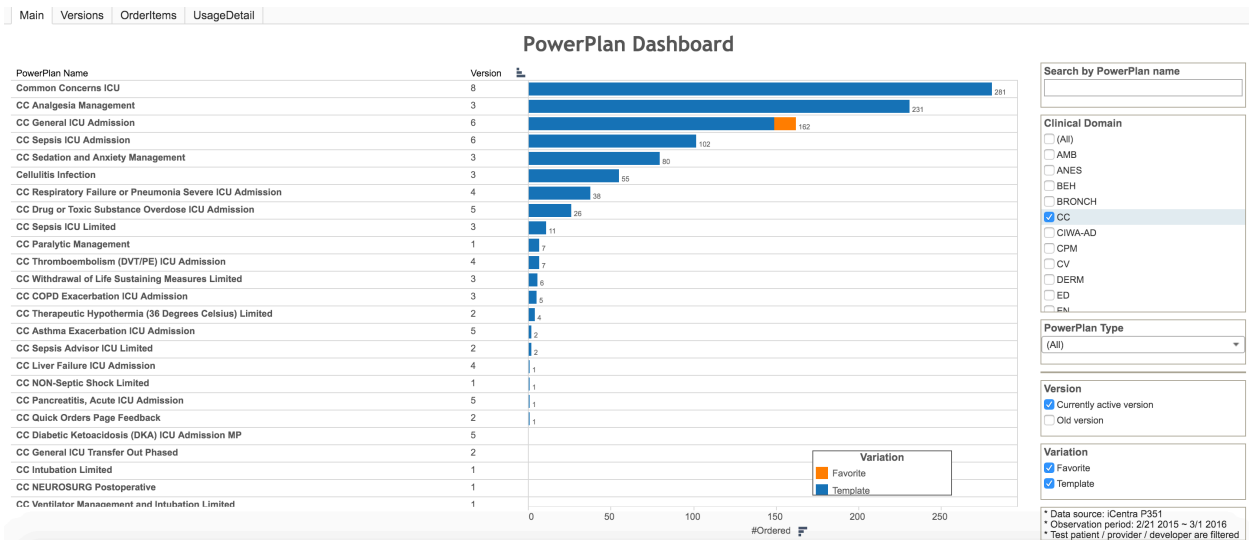


Figure 2 - Main view of order set utilization dashboard, showing content, usage data, filters, and order volume derived from the main template and its associated favorites. This specific view is focused on order sets in the Critical Care (CC) domain.

Figure 3 presents a graphical view of overall usage of an order set over time, also with baseline template and favorite ordering volumes depicted. Dynamic filters allow the user to focus strictly upon specific regions, facilities, roles, or timeframes of interest to the user. Drill-down capability allows the user to select portions of the display and view only the data that pertains to the selection itself.

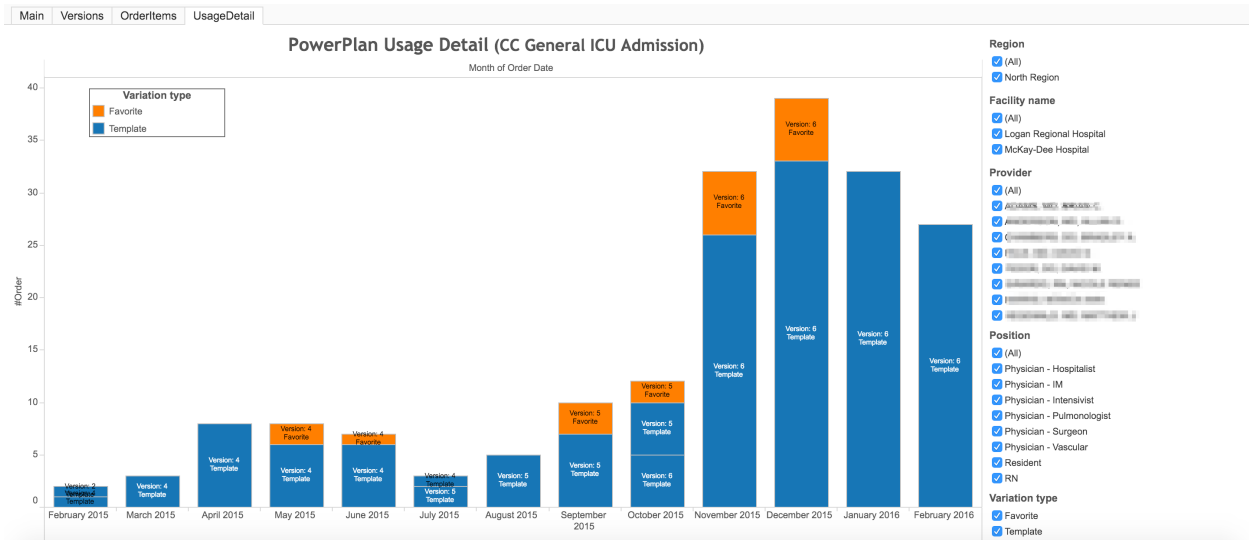


Figure 3 - Time-based view of ordering patterns for a specific order set (CC General ICU Admission) in the Intermountain Healthcare order set catalog. Version, order volume, order session type, and associated dynamic filter sets are shown.

Figure 4 shows the ‘phylogeny’ of an order set, including timestamps, authors, and difference counts across the main versions of the order set itself. It further shows detail about the ordering physicians that have taken time to create favorites against the template, including timestamps, names, counts and drilldown views into the changes made in the favorite, and data regarding the number of times in which the favorite was used. At a high level, it illustrates the branching and evolution that can occur in the main order set template and the favorites derived from it.

Figure 5 depicts a line-item view into the details of an order set. When set to show all versions, the visual cue of color blocks next to each of the orders demonstrates the presence or absence of an order from a particular version of an order set. When viewed against the entire version history of the same content (or against favorites derived from the template) the color patterns show the evolution of the content itself, including orders that are added, removed, or updated over time. The color of the blocks themselves represent selection status in this view, indicating whether the order was preselected or not. Numbers across the top show the various versions of the content itself, as well as corresponding ‘denominators’, which indicate the number of times in which that particular version of an order set was ordered against. Numbers overlaying the orderable blocks themselves show the frequency with which particular orders were ordered against in the ordering sessions that used these order sets.

Main Versions OrderItems UsageDetail							
Version and Favorite (CC General ICU Admission)							
Version	Variation	Favorite Name	Create date (Update date / update count)	Author/Position	#Order	#Modific..	
1	Template		2014-01-03 (2014-07-15 / 185)		0	0	
	Favorite	Borgeson_ICU General Admission	2014-06-09 (2014-06-09 / 0)		0	5	
		Borgeson_ICU General Admission	2014-07-08 (2014-07-08 / 0)		0	1	
		Borgeson_ICU General Admission	2014-07-08 (2014-07-08 / 0)		0	2	
2	Template		2014-07-15 (2015-02-11 / 24)		1	0	
	Favorite	ICU General Admission D Pt1	2014-08-05 (2014-08-05 / 0)		0	19	
		ICU General Admission C Patient 1	2014-08-05 (2014-08-05 / 0)		0	14	
		ICU General Admission C1 pt	2014-10-07 (2014-10-07 / 0)		0	32	
		ICU General Admission - ICU C1	2014-10-09 (2014-10-09 / 0)		0	32	
		ICU General Admission - ICU C1-Copy	2014-10-09 (2014-10-09 / 0)		0	22	
		ICU General Admission - ICU C1	2014-10-09 (2014-10-09 / 0)		0	33	
		ICU General Admission - ICU C1	2014-10-09 (2014-10-09 / 0)		0	33	
		ICU General Admission	2014-10-22 (2014-10-22 / 0)		0	21	
		ICU General Admission	2014-10-22 (2014-10-22 / 0)		0	23	
Admission General ICU JSS	2015-02-09 (2015-02-09 / 0)		0	0			
3	Template		2015-02-11 (2015-02-11 / 3)		0	0	
4	Template		2015-02-11 (2015-07-13 / 16)		27	0	
	Favorite	CC General ICU Admission MSW	2015-02-17 (2015-02-17 / 0)		0	5	
		CC General ICU Admission icu	2015-02-20 (2015-02-20 / 0)		0	0	
		CC General ICU Admission graham	2015-04-07 (2015-04-07 / 0)		0	9	
		CC General ICU Admission	2015-04-09 (2015-04-09 / 0)		0	1	
		CC General ICU Admission	2015-04-11 (2015-04-11 / 0)		0	7	
		CC General ICU Admission	2015-04-11 (2015-04-11 / 0)		0	15	
		CC General ICU Admission	2015-04-13 (2015-04-13 / 0)		0	17	
		CC General ICU Admission	2015-05-05 (2015-05-05 / 0)		0	17	
		ICU Chest Pain obs	2015-05-09 (2015-05-09 / 0)		1	32	
ICU Chest Pain obs	2015-05-09 (2015-05-09 / 0)		1	38			

Figure 4- Version and Favorites Tree for the CC General ICU Admission Order Set from the Intermountain Healthcare order set catalog. This view shows the version history, favorites branches, as well as the corresponding timestamps, authors (names and roles), number of ordering instances, and modification counts derived from each knowledge artifact.

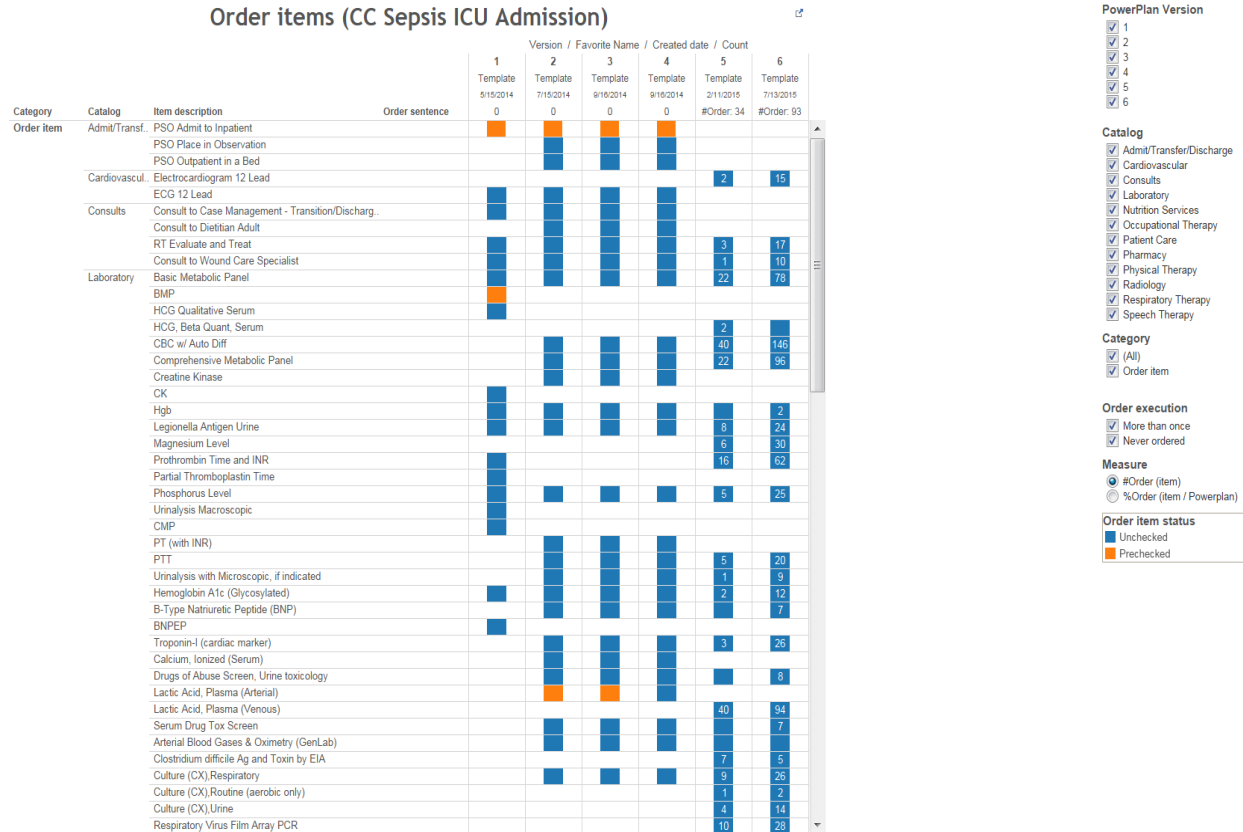


Figure 5- Line Item view inside the CC Sepsis ICU Admission Order Set. This view shows each order within the order set and depicts its presence/absence in the version history, as well as actual ordering data that corresponds with each element. Corresponding 'denominators' are found in the column headings that match each version.

This dashboard utility and these specific visualizations have allowed us to compile useful information about the scope of our current order set catalog and the extent to which it has been revised and used. It has also given us new insight as to the frequency with which our users are using personalized order sets to find, tailor, and adjust the enterprise order sets themselves. The insight is useful both in comparisons of templates to their derived 'favorites' collections, as well as across versions of the enterprise order set template itself.

Results

Our efforts in extracting these data sets and consolidating them have allowed us to summarize and describe the artifacts in the order set catalog itself. Table 1 contains data pertaining to the main order set templates in the library itself, their usage to date (with the understanding that our enterprise installation is still in early phases), and the number of authors responsible for the content. It shows that less than half of the available enterprise order sets available in the order set catalog have been used to date.

Table 1. Summary data for enterprise order set template data in Intermountain's order set catalog

TEMPLATE DATA				
Order Set Type	Care Plan	Phased	Pathway	Future Encounter
Order Sets available	2,516	4,366	758	4,838
Used – to date –	970 (39%)	1,725 (40%)	386 (51%)	390 (8%)
Not Used – to date –	1,546 (61%)	2,641 (60%)	372 (49%)	4,448 (92%)
Total # of Usage Instances	131,498	137,869	3,134	4,785
Grand Total of Usage Instances	270,118			
Unique Content Authors	107			

Table 2 summarizes similar data for favorites saved to the order set catalog as well as corresponding usage data. This table contains two fewer order set types, as users do not have the ability to set favorites on future (day of treatment) and phased order sets in the Cerner system. It also shows how many order set templates have been ‘favorited’ and the average number of favorites per ‘favorited order set’. This table also shows the number of ‘cloned’ favorite order sets, in which the user has personalized the order set in name only (the content of the personalized order set does not differ from that of the template from which it was derived).

Table 2. Summary data for personalized or ‘favorites’ order set data in Intermountain’s Cerner order set catalog

FAVORITES DATA		
Order Set Type	Care Plan	Pathway
Favorite Order Sets available	8,787	6694
Derived from unique order sets	693	275
Average # of favorites per ‘favorited template’	12.7	24.3
Used – to date –	3282 (37%)	3307 (49%)
Not Used – to date –	5505 (63%)	3387 (51%)
Total # of Usage Instances	22,670	15,773
# that are exact copies of template (clones)	954 (11%)	509 (8%)
Unique Content Authors	1424	

Figure 6 depicts the additions to the collection over time as authors added to and updated existing content in the set. It shows additions to the order set catalog in the year prior to the initial go-live in Intermountain’s Cerner installation (February 2015). Favorites are shown in orange, while main templates and revisions are shown in blue.

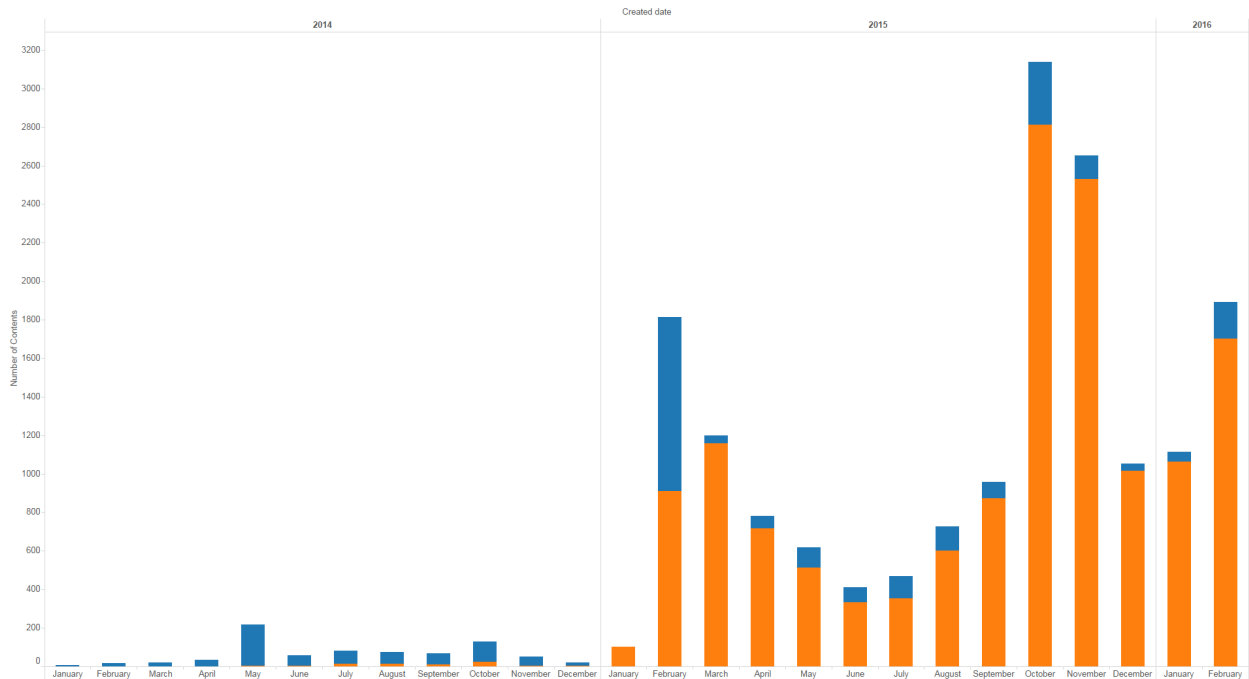


Figure 6 - Content additions to the Intermountain order set catalog (consisting of both enterprise order set templates in blue and the entire personal favorites catalog in orange) in 2014 through early 2016. Enterprise order sets and revisions are shown in blue, personalized order sets or ‘favorites’ are shown in orange.

Figure 7 shows the overall volumes of orders derived from order sets coming into the database from the initial enterprise installation to present (February 2015 to February 2016). This graph, combined with the data shown in

Tables 1 and 2 shows that despite the large numbers of favorites available in the Intermountain order set catalog, most of the order volume derived from CPOE is coming from enterprise template order sets, not favorites. Growth in the volumes shown in the order curve are derived largely from new sites and regions coming online with the new Cerner EHR system.

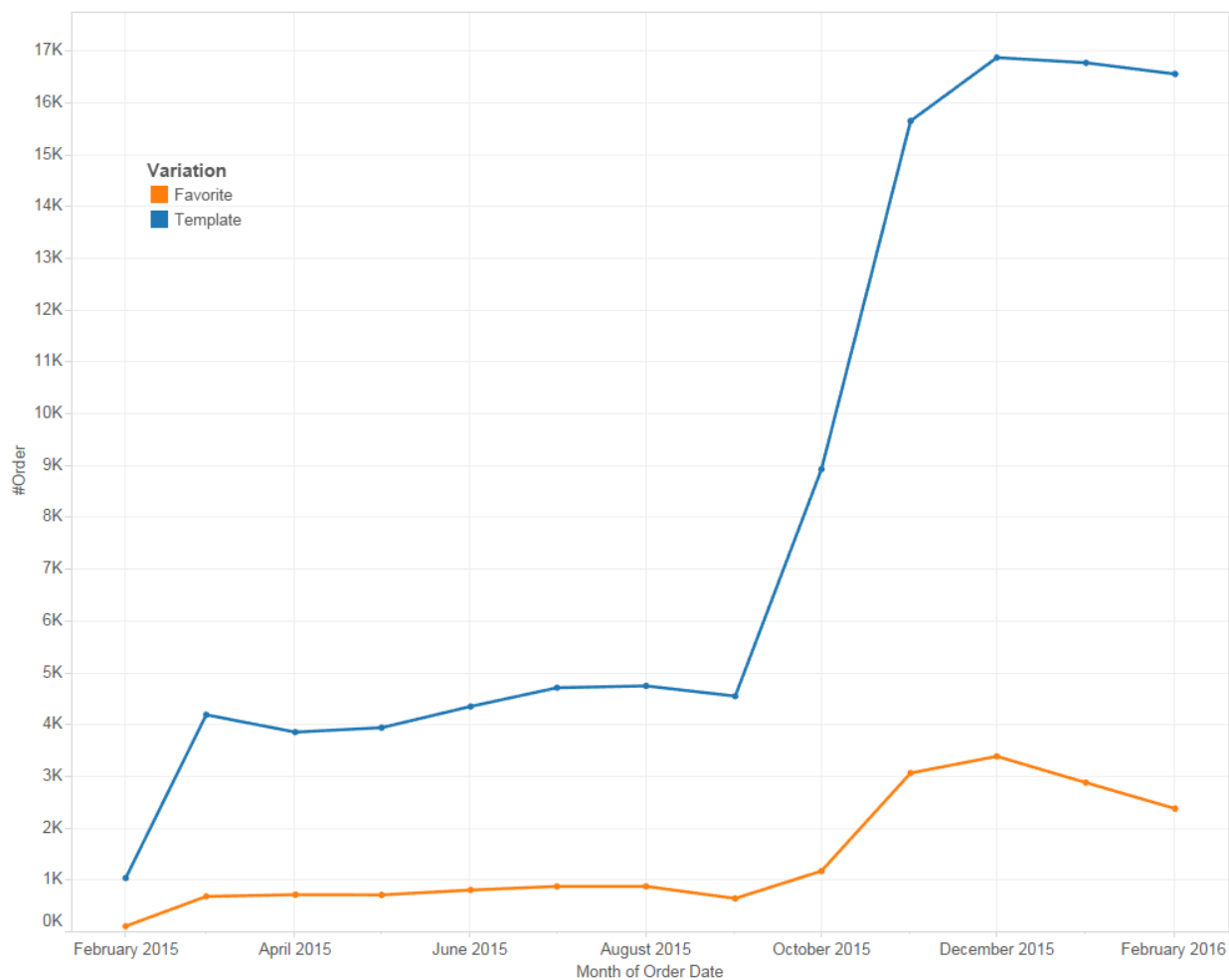


Figure 7 - Order Set usage data since initial Cerner implementation at Intermountain Healthcare. Order sets entered via 'favorites' are shown in orange, enterprise-level content is shown in blue.

Discussion

We have constructed tools that allow order set content owners to quickly identify their content, view its utilization over time, and understand specific details of how, where, and who is using the content. Further, material views make it relatively straightforward for content owners of order sets to understand how their content is being used. As we have developed and presented these views back to the clinical teams responsible for the content, they have expressed both interest and enthusiasm in being able to quickly visualize how and where their content is being used. Several key themes have emerged as we have reviewed this data and presented it back to users.

Departmental differences over Favorites

Different departments and clinical programs inside Intermountain Healthcare have strikingly different views on the place of personalized order sets within a CPOE system. Some clinical groups (like cardiology) are patently opposed to users utilizing them and have configured the system to disallow specific user roles from creating them. Other departments are much more relaxed in this regard and go as far as encouraging them and training users how and when to go about it. As a result of these differences, departmental level views of order set utilization can be very different, with cardiology-specific content showing almost no utilization of favorites, to the other extreme in

obstetrics/gynecology where over 70% of postpartum discharge orders are entered via favorites. Despite the difference in philosophy or approach on personalized order sets, both departments have expressed value in being able to visualize the usage patterns of their content.

Namespacing or 'initialing' of content

As shown in Table 2, between 10 and 15% of all favorites in the Intermountain catalog are exact copies of the enterprise order set from which they were derived, or 'clones'. In many cases, the only material difference between these personalized order sets and the templates from which they were built is the name. Many users applied a namespacing approach in which they prepended or appended their initials to the title of the order set. Others renamed them to facilitate searching using terms they would think of when using the search mechanism of the Cerner CPOE system. Due to the updating features of the Cerner EHR system, these users' content will remain consistent with the enterprise template as it evolves.

Content gaps

The phylogeny-based view of the order set content also revealed interesting perceived gaps in the order set catalog itself. Simple inspection of the obstetrics/gynecology order set data showed large amounts of favorite use in the postpartum discharge order sets. Upon inspection of the favorite sets built against this template, key themes emerged from the order set titles, in particular the groundswell of desire from the users to separate the content into separate groupings of 'C-section discharge orders' and normal or vaginal delivery C-section orders. When content authors originally built this order set, they had grouped these two use cases (post C-section discharge orders and normal vaginal delivery orders) into one order set intended to support both. Yet the users' creation and subsequent use of these two separate 'favorites-based' sets indicates a strong preference for separate content to support both scenarios. This type of feedback allows content owners to revisit and potentially re-prioritize content development efforts.

Unused content

In both the enterprise order set and favorites libraries there were significant numbers of order set templates that have not yet been used. This is not entirely unsurprising, as Intermountain is still relatively early in its implementation of the Cerner EHR system. The significant number of unused 'favorites' is somewhat more difficult to characterize, though some of that may be due to content created by physicians during their training with the software or time with physician coaches who are orienting them to the features present in software that is unfamiliar to them.

Over time, this usage data may bring to bear content that is present in the library, but semi-obsolete from a utilization perspective. Seldom-used order sets may be considered for deletion from the library in such circumstances, so as to optimize the users experience with the software, as well as to minimize the already significant maintenance costs that come with keeping them current with best practice and standards given in the medical literature.

Some clinical groups have been a bit surprised by the utilization data, in that they have in some cases created content that is rarely used. Some clinical workflows and even training routines that are part of implementation favor other methods for ordering, including quick orders, workflow-driven wizard screens and other modules. In some of these cases, content owners have shifted some of their focus away from order set development for all scenarios, targeting instead those where they feel that other options don't address the clinical users' needs adequately.

Ownership/governance

Tables 1 and 2 illustrate the scope of authors required to create the order set library that we are characterizing. It details that there are just over one hundred content authors who maintain the enterprise order set library and well over 1400 individuals that have personalized order sets. At Intermountain, the order set creation and update effort is spread across clinical programs at the corporate level, with regional representation from the various sites/regions and input from clinical, administrative, and central groups (e.g. compliance, legal, etc). It also has input from clinical service lines, local units, physician champions and specialists. Clearly there are many other individuals beyond the 100+ specific content authors who are expending significant effort in curating/refining content in the enterprise content development teams. The overall effort necessary to build these libraries is significant.

Order volume

Figure 7 shows that most of the order volume derived from order sets does indeed come from enterprise-level order sets, and not from personalized ones. More than 80% of the volume collectively comes from the standard content.

There are clear exceptions to this, as noted above, and these differences may reflect different philosophical approaches in clinical divisions, content gaps and/or other reasons specific to the users. Our hope is that presenting these data to content stewards can stimulate meaningful conversation amongst authors and users of these knowledge artifacts to optimize users' experience with the order sets.

Limitations

We have not looked at complete ordering patterns within the Cerner toolset, only those derived from order sets. Quick orders and other workflows support ordering and encompass the broader picture of medical orders in the clinical setting. Our analysis has not yet extended itself to differences in order sentence construction. We have also not yet undertaken the visual analysis of phased or component order sets which are common to multiple parent or pathway order sets.

Next Steps

We intend to extend the capabilities of the visualization toolset to drill down to the details of the orderable/order sentence level, further illustrating the specifics of how the orderables are being used. We also plan to work with clinical analysts from each of the clinical specialties to begin to attach cohort specifications as an applicable filter for viewing order set utilization data (e.g. to show usage of the febrile infant order set specifically for patients who met the febrile infant definitions from the clinical data).

Acknowledgments

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Conclusion

We have constructed tools that allow order set content owners to quickly identify their content, view its utilization over time, and understand specific details of how, where, and who is using the content. Materializing this information visually has illustrated some key themes of content usage, needed areas for refinement, and greater visibility into the actual consumption of knowledge content produced by central content teams. We anticipate that this vision into the data will lead to optimization and enhancement of content over time.

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