A Simulation Modeling Approach to Understanding Workflow Changes in Healthcare: The Case of CPOE Deployment at The Ottawa Hospital

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Abstract
This work describes and illustrates the use of simulation modeling for evaluating and analyzing the impacts of workflow changes in healthcare resulting from the deployment of a computerized provider order entry (CPOE) system. It is motivated by our longitudinal research program which purports to explore simulation modeling as one of the means that can be applied not merely to contribute to an increased acceptance and use of CPOE systems, but also to aid in decision making. The setting used is The Ottawa Hospital, one of the Canada’s largest teaching hospitals, and its multi-phase, multi-year CPOE deployment project for laboratory and diagnostic imaging orders to improve both patient safety and quality of care. The preliminary results indicate that the proposed simulation-based tool can be effectively applied in its current level of development to quantitatively evaluate and compare different options of workflow changes within a given set of operational and organizational constraints.

1. Introduction

Computerized provider order entry (CPOE) systems are used by healthcare clinicians to place orders for medication, laboratory and diagnostic imaging tests, and other services [1-3]. Their deployment is a key step to digitize healthcare processes. They offer an alternative to handwritten and paper-based ordering system primarily to reduce errors, delays, and duplication in transcribing by physicians and other clinical providers. The expectation is that the use of a CPOE will result in less medical transcription errors, greater workflow efficiency, greater satisfaction and confidence of clinical practitioners, rapid communication of orders, and in significantly enhanced decision support capabilities compared to traditional handwritten orders [3, 24]. Despite these potential benefits, successful implementation of CPOE systems is known to be difficult and expensive [4-5]. Therefore, after many years of efforts, the number of hospitals with fully functional CPOE systems in place remains limited [3]. For example, it is reported in one survey that less than 10% of US hospitals have implemented CPOE [24]. Another study conducted in seven Western countries reported that the implementation of CPOE is still slower and more problematic than anticipated, with the highest market penetration found in the Netherlands [26]. The potential to change clinical workflows and its consequence to patient safety has been recognized as one of the central issues for their deployment and implementation [6, 27-28]. Other unintended adverse consequences that surround a CPOE implementation and their impacts on clinical end-users who use, maintain, or manage CPOE systems also contribute to the level of user acceptance of these systems and their success of adoption. These consequences, which need to be understood and managed, have been clustered in various major categories [7, 24]: e.g., more/new work for clinicians, unfavorable workflow issues, never ending demands for system changes, problems related to paper persistence, changes in communication patterns and practices, negative emotions, new types of errors, unexpected and unintended changes in institutional power structure, and overdependence on technology. CPOE diffusion is shaped, to a large extent, by how organizing visions about the innovation is legitimized in practice [8].

With these challenges ahead, the Ottawa Hospital, one of the Canada’s largest teaching hospitals, has embarked on a large investment program of various health care information technologies and their integration to deliver better patient outcomes. This includes a multi-phase, multi-year deployment project of a CPOE system (mobile via iPad and desktop) for laboratory and diagnostic imaging orders with the aim of improving both patient safety and quality of care. The project rollout involves three campuses that have a total capacity of 1170 inpatient beds, have more than 12000 employees (including 1250 physicians), and handle on a yearly basis about 3600 residents, 2000 volunteers, 47000 admissions, 60000 surgical cases, and 135000 emergency visits. Executives of the hospital who are in charge of establishing policies and procedures, assuring
compliance with regulations, and making CPOE-related resource allocation decisions were concerned about means to reduce barriers to adoption and increase user acceptance. Therefore, an acceptance strategy was put in place consisting of (a) transitioning to CPOE with an hybrid model of both paper and digital orders in which only one unit at time and a small subset of the clinician population within the unit is exposed to the new system, allowing for changes to be done early on to improve the overall functionality of CPOE before expanding its exposure to other clinicians and units [9]; (b) engaging users in the design and deployment phase of the CPOE system to develop a community initiative, where responsibilities and attribution of success are shared with all stakeholders [10]. The key assumptions underlying this strategy are that (1) clinician resistance would emerge as calls for responses to changes identified during the use of the system will grow and thereby negatively impact user acceptance of the CPOE system and the intention to use it, and (2) user engagement would attenuate barriers to adoption and thereby positively impact the user acceptance of the CPOE system and the intention to use it.

The authors in [10] have shown findings that are consistent with TOH’s expectations of engaging users. Perceived usefulness and perceived ease of use, two proven predictors of the intention to use health information technologies were used in the analysis as well as psychological ownership as a measure of psychological attachment resulting from engaging users in the development and deployment process. The study indicates that an increased psychological ownership has a strong and significant partial mediation on the impact of resistance to change (by counteracting the effects brought by the perception of threat and risk) on perceived usefulness and on user acceptance. In their preliminary analysis, the authors did not discuss the means through which this goal can be accomplished. Accomplishing legitimization and eventual mobilization and use of new information technology-based information systems have long been recognized as a complex endeavor involving a multiplicity of actors and institutional processes [11]. Finding ways to further explicate taken-for-granted notions of how organizations, in practice, innovate with technology may serve to increase the success of technology adoption, mobilization, and use.

In this in-progress longitudinal research program we explore simulation modeling as one of the means that can be applied, not merely to contribute to an increased acceptance and use of a CPOE system, but also to assist in decision making. We use the graphical animation capability of simulation software to visualize and demonstrate how work changes contribute to the overall system success or problems. Simulation modeling applied to systematic process redesign, delivery and roll-out in a hospital-based clinical setting has attracted the attention of academics and practitioners to improve the safety, effectiveness, and efficiency of health care services [12-13]. We choose it over other modeling approaches (e.g., optimization), as it doesn't require simplifying assumptions and it offers better options (and flexibility) required to handle the nature of constraints, complexity, uncertainty, and risks involved in the provision of healthcare. Moreover, it provides a risk-free environment in which changes can be understood prior to formal release into service. It is also much easier to explain to various stakeholders in order to obtain their buy-in (after they understand the model and place a great confidence in its results), a crucial step in moving from predictions to decisions and implementations.

Therefore, the objectives of the research program are to: (1) produce a tested and validated instrument with diagnostic and predictive capabilities that offers the opportunity to more effectively scope the range of potential benefits (or loss) from changes identified during the use of a CPOE system; (2) use the instrument in various situations (e.g. in the training strategy) to provide, through its animation capability, deeper insights into the barriers or incentives to adoption and assess how a better understanding of the impacts of proposed changes to the overall test ordering process would contribute to an increased acceptance and use of a CPOE system; and (c) use the instrument as a risk-free environment, where workflows as planned can be “bench-tested” prior to their release, the gap with workflows as enacted in practice after their release can be evaluated with relevant metrics, and the strategy to reconcile this gap can be tested, demonstrated (e.g., using the animation capability of the instrument), and quantitatively measured to identify and promote good practices or dissuade the bad ones.

This paper seeks to answer the first objective of this longitudinal research and sets directions for the other research objectives. We describe and exemplify the use of simulation modeling for evaluating and analyzing the impacts of workflow changes in healthcare resulting from the deployment of a CPOE system. Our modeling approach consists of building a logical model of the system with a computer and experimenting with it for insights. Hence, it differs with another type of simulation reported in the literature which consists of replicating the system prior to its release with realistic scenarios where clinicians interact with the system and other technologies involved in the workflow (e.g., [14-16]).
With this type of simulation, sessions are recorded in various devices and data are analyzed to identify usability problems as well as changes in workflows. In building our model, we resorted to principles and concepts commonly used and applied for conducting a valid simulation study (e.g., [17-20]). The paper is organized as follows. An overview of CPOE work processes is discussed in section 2. We discuss our modeling and simulation model in section 3. We report our preliminary results in Section 4. Finally, conclusions and plans for future work are presented in Section 5.

2. Overview of CPOE test ordering workflows

The workflow used to place, review, authorize, and carry out orders when adopting a CPOE might appear to follow predictable steps [21-22]: a clinician places one or many orders on a CPOE system (after a selection process), flows of information about orders are routed to various stakeholders, orders are processed (i.e., specimens are collected and sent to laboratory), orders are executed (i.e., specimens are processed and analyzed), flows of information about orders are routed back to various stakeholders (including result reporting and interpretation). However, the process used in practice is much more complex than the steps reported above can possibly represent. It is more adaptable; contains other steps to facilitate the many interfaces with other stakeholders; involves competition between limited resources and a division of labor; and includes a variety of checks, balances, interventions, and exceptions [7, 23].

Figure 1 shows an overview of workflows at the Ottawa Hospital for both laboratory and diagnostic imaging orders. These workflows describe the redesigned abstract patterns of the organizational processes and structures as altered in support of the use of a CPOE test ordering system. We briefly discuss below each of these workflows.

2.1 Laboratory ordering workflow

CPOE laboratory ordering workflow at TOH as planned can be summarized as follows [9]:

(a) A clinician logs in to access CPOE, chooses the correct roster, selects the appropriate patient, the type of orders (biochemistry, hematology, and microbiology) and the type of tests to submit within each order type.

(b) The submitted orders appear on the clinical whiteboard as well as on TV screens at the nursing stations. These provide a snapshot as to who the patient is, where they are located, any important notes about them, and pending laboratory tests. A flag appears when there are new orders that the nurse must check and subsequently complete. If the order has a priority of STAT, the test must be completed immediately. The nurse is then responsible for using the Bridge application to generate the required labels, and for obtaining the specimens. Laboratory tests that have been assigned a ‘now’ due date or are originally placed as a STAT will have a reference instance # created immediately (also known as an accession #). The assigning of an accession # changes the status of the order on the eKardex from ‘ordered’ to ‘scheduled’. The nurse logs into Bridge and scans the barcode on their own ID badge. They then scan the patient’s hospital ID bracelet and choose the desired test to be performed. The accession # links the test with the patient; this information is printed via a wireless printer and label(s) is/are affixed to the test tube(s). The nurse draws the specimen and scans the bar code on the label/specimen. This final scan by the nurse causes the order to change from “scheduled” to “completed”. The specimen is then transported via the pneumatic tube system (a pressurized tube system that links all nursing units to the laboratory) or via a transportation worker/porter.

(c) If the order is a routine priority (as opposed to a stat), it is added to the system as an active order, but it will not receive an accession # until the day of the test as the information system that governs laboratory information (i.e. Cerner) will only allow orders to be active for a period of 24 hours. On the day that the test is assigned for, the clinician (typically a nurse or a phlebotomist) completes the same process as above (see b) using the bridge application to ensure the validity of the specimen.

(d) Once the lab receives the specimen, the technologist scans it using Bridge. This causes the status of the order to change in CPOE from completed to inactive. This means that the laboratory ordering process is complete (even if the laboratory still has to process the specimen and send a notification via the clinical whiteboard when results will become available.

2.2 Diagnostic imaging ordering workflow

CPOE diagnostic imaging (DI) ordering workflow at TOH as planned can be summarized as follows [9]:

(a) The clinician logs in to access CPOE, chooses the correct roster, selects the appropriate patient, the type of DI orders known as modalities (angio, breast
imaging, computed tomography, general x-ray, magnetic resonance imaging, nuclear medicine, ultrasound, and ultrasound obstetrics/gynecology) and the type of tests to submit within each modality type. Some DI orders require what is referred to as ‘online protocoling’. Essentially, a radiologist must review the order request and determine whether the test should be done and how the test should occur. If the test requires online protocoling, the patient should be listed in the appropriate area. The radiologist then reviews the patient’s history in combination with the request details. The purpose is to determine which protocols should be applied, whether contrast (for easier viewing) should be used, and set the priority which corresponds to the wait time until the patient receives the test.

(b) The submitted orders appear on the clinical whiteboard as well as on TV screens at the nursing stations. These provide a snapshot as to who the patient is, where they are located, and any important notes about them. A flag appears when there are new orders that the nurse must check (and subsequently complete). Orders are then routed through the Radiology Information System (RIS) which is located within the SMS application used for both scheduling and billing purposes.

(c) If the order does not require online protocoling, then the DI booking clerk for the specific modality will proceed in booking the patient’s procedure time. If the test being ordered does require online protocoling, the patient will be registered in RIS but their procedure will not be scheduled until the protocoling is complete. The registration indicates that the DI modality booking clerk is awaiting the results from protocoling. Once the protocoling is complete, and the radiologist has approved the procedure, the DI modality booking clerk schedules the procedure for the patient and registers them. This information is updated on the clinical whiteboard so that the nurse can plan to ensure that the patient is properly prepared and on-time for their procedure appointment time. In the event that the radiologist declines the procedure request, the order must be cancelled within RIS because it was created there when the order was initially placed.

(d) On the day of the procedure, the test will appear on the clinical whiteboard so that the nurse can ensure the patient is ready to go. Once the procedure has been completed, the technologist performing the exam will update RIS to indicate the exam is now complete. This action will cause the order to change from active/scheduled to inactive in CPOE.

3. Modeling and Simulation

The modeling of ordering workflows described above is very complex due to the nature of the activities involved. The complexity stems from a variety of elements to take into account such as types of orders (laboratory, diagnostic imaging, mixed), types of tests for a laboratory order, types of modalities for a DI order, test priority (STAT, NOW, ROUTINE), a DI modality status (online protocoling, no online protocoling), clinicians involved (nurse, phlebotomist, radiologist, physician), among other elements.

One possible modeling approach is to use the “pull” approach where the current schedule of orders arriving is used to generate orders in the system. Because of its lack of generalization, a “push” modeling approach is instead used consisting of randomly generating incoming orders and their types and processing times based on artifacts of the working environment that were collected and analyzed, such as protocols, guidelines, and policies.

As pointed out above, in building our model, we resorted to principles and concepts commonly used and applied for conducting a valid simulation study (e.g., [17-20]).

3.1 Overview of the stages involved in the push simulation model

Figure 2 presents an overview of the main modules involved in our push simulation model.

Figure 2: Overview of the simulation modules

The patient generation module (PGM) takes its inputs from various probability distributions, protocols and policies to generate for each patient, an ID, an order type, the types of tests, the number of tests of each type, and the priority of each test. The laboratory order processing module (LPM) is used to assign laboratory orders waiting for processing to a
clinician (nurse or phlebotomist), route a clinician to patients, and set the number of specimens to collect for each patient to visit as well as the specimen patient collection complication level and the collection time as per the patient complication level and other technical issues (e.g., loss of WIFI, etc.). The diagnostic imaging order processing module (DPM) is used to handle DI orders waiting for processing as per their modality status (online protocoling, no online protocoling) and the radiologist schedule. The System display module (SDM) is used to track and display the status of various orders in the system, a set of information commonly found on the clinical whiteboard, and various other descriptive statistics.

3.2 Input modeling and analysis

The data inputs were determined through data collection and interviews with various clinicians (nurses, phlebotomists, physicians, radiologists). The data analysis allowed us to determine (a) the clinician schedules; (b) various policies (e.g., waiting time standards for tests with STAT priority, scheduling and availability of nurses versus phlebotomists, etc); and (c) various input distributions required in the simulation model such as types of orders, types of laboratory tests, types of DI modalities, priority of tests, specimens per order, specimen collection time, specimen collection difficulty level, collection preparation time, online protocoling time, and the number of patients per specimen collection visit.

3.3 Model building and translation

The model has been developed using Arena software. The key entities are orders of various types belonging to a limited number of patients to be processed in the system. The following assumptions were adopted:

- The number of orders arriving throughout a day follows a nonstationary Poisson process.
- The working schedule of clinicians is known and will remain unchanged.
- The specimen collection solely involves blood collection.
- Processing requests are on a first come and first serve basis.
- The system operates on a schedule running 24 hours per day.
- All submitted orders must be processed (i.e., cancellation of a submitted order is not permitted).

3.4 Model verification and validation

We resorted to a structured walk-through approach, the face validity, and the Turing tests to proceed to the model verification and validation [18]. Therefore, the logic of the model and its representation using the animation capability of Arena were presented to various stakeholders with knowledge of the system to ensure that the model is a good representation of it. In addition, some aggregate measures of processing times (minimum, average, and maximum) at different key steps were collected and presented to the same knowledgeable individuals in order to determine that the model and/or its behaviour is reasonable.

4. Preliminary use of simulation model and findings

The model was used to conduct a pre-testing experiment to scope the range of potential benefits (or loss) if workflow changes identified from the use of the CPOE system were implemented. We limit the experiment not to the Ottawa Hospital as a whole, but to two units (medicine and family medicine) located in one of its three campuses. As we stated in the introduction, a deployment strategy consisting of an incremental implementation was adopted. Within this strategy, a small pilot implementation precedes any further CPOE deployment, which can be paced at a penetration rate the organization is comfortable with. At the completion time of this study, the CPOE system has only been deployed in few major units. We selected the ones with the highest degree of maturity in the utilization of a CPOE system. The base scenario consists of the current order workflow as planned (i.e., the redesigned abstract patterns of the organizational processes and structures as altered in support of the use of a CPOE test ordering system). The alternative scenarios are workflow changes as enacted by the practice (i.e., the organizational processes and structures as enacted in practice to respond to unforeseen disruptions precipitated by the use of CPOE). In order to generate our alternative scenarios, we conducted semi-structured oral interviews to a sample of 20 nurses working in our two units, where a CPOE system is currently deployed to handle laboratory tests ordering and monitoring. Table 1 includes a list of questions that served as a starting point for these interviews. The interviewees were asked about their experience with the CPOE system, the challenges that are arising from its utilization and how they are coping with them.
Table 1: Sample of questions used for semi-structured interviews

<table>
<thead>
<tr>
<th>Number</th>
<th>Introductory question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Could you please briefly describe your background and professional experience?</td>
</tr>
<tr>
<td>2.</td>
<td>How has CPOE impacted time required to place orders?</td>
</tr>
<tr>
<td>3.</td>
<td>Has the time required to complete daily nursing tasks increased, decreased or remained about the same since the implementation of CPOE?</td>
</tr>
<tr>
<td>4.</td>
<td>Are there any processes still completed on paper? How your work routine impacted by this?</td>
</tr>
<tr>
<td>5.</td>
<td>What (if any) modifications would you like to see to CPOE</td>
</tr>
<tr>
<td>6.</td>
<td>What is the one or two biggest changes to your daily work?</td>
</tr>
<tr>
<td>7.</td>
<td>Were there any workarounds you had to use during the initial weeks of CPOE? Do you still use workarounds?</td>
</tr>
<tr>
<td>8.</td>
<td>How has CPOE impacted communication amongst clinical staff?</td>
</tr>
<tr>
<td>9.</td>
<td>What has your experience been with transferring or discharging patients?</td>
</tr>
<tr>
<td>10.</td>
<td>Any final comments, thoughts, critiques</td>
</tr>
</tbody>
</table>

From the data analysis, the following alternative scenarios were considered in our preliminary research:
(a) changes in workflows arising from handling “add-on patients” (scenario 1);
(b) changes in workflows arising from handling “add-on” tests (scenario 2);
(c) changes in workflows arising from handling in a non-emergency unit critical orders for trauma cases and emergency cases (scenario 3).

The first scenario deals with an unforeseen reported issue that emerges to handle patients that have checked-in, but are yet to be registered at the CPOE unit (e.g., when transferred from a non-CPOE unit). For these “add-on patients”, their orders cannot be placed in CPOE. This creates an increase in coordination load with other stakeholders (e.g., needs to determine which tests have been ordered, which tests have been processed, etc.). The second scenario deals with issues that emerge to handle orders with tests not available for selection on CPOE or when clinicians request subsequent tests on the unused portion of the sample remaining in the laboratory. For these “add-on tests”, a paper-based system is in place requesting an increased coordination and attention, especially when the same patient has orders submitted both via paper and digital systems. Finally, the third scenario deals with “add-on emergency” that occurs when a patient in a non-emergency unit setting requires critical tests immediately; but the process dictates that the order must be submitted via CPOE. Patients with “add-on emergency” do not have the time to wait for orders to be submitted; hence, the need to bypass some steps of the CPOE ordering process.

We applied our simulation model to a setting that represents 7 days of operation (i.e., one week) and 24 operating hours per day. The number of replications was set to five (5) hundred. Table 2 presents the summary descriptive statistics of the volume of orders to be processed in the case of the basic scenario.

Table 2: Summary descriptive statistics of volume of orders (basic scenario)

| Maximum number of patients | 70 |
| Total number of orders    | 415 |
| Total number of laboratory tests ordered | 1092 |
| Total number of laboratory tests with STAT/NOW priority | 230 |
| Total number of laboratory tests with ROUTINE priority | 862 |
| Total number of DI tests ordered | 295 |

The output measures considered are respectively the service level standard, the maximum throughput (MTP), and the average turnaround time. The MTP corresponds to the percent of orders processed by the system during a given period of time (one week in our case). It provides a proxy of the responsiveness level of the system to an increased demand (i.e., volume of orders). The service level provides a proxy of the system in meeting the service standards (in compliance with the existing policies). It applies to tests with STAT or NOW priority. It is measured by the lateness (or readiness) of orders. The lateness (readiness) of an order is measured by the proportion (RR) of orders that have been processed within the time limits defined in the TOH’s service standard booklet. The turnaround time (TDT) defines the elapsed time from the creation of a test to the end of specimen collection and transport to the laboratory test. It applies to laboratory tests with ROUTINE priority.

Table 3 presents a summary of our findings. Our results show that although the system still has a high responsiveness to changes in workflows (MTP remains at 100% in all scenarios), workflows changes have negative impacts on the service level (a decrease in the lateness ratio and an increase in the average turnaround).
Table 3: Impacts of Workflow changes on MTP, lateness, and turnaround time

<table>
<thead>
<tr>
<th>Scenario</th>
<th>MTP (%)</th>
<th>Lateness Ratio (%)</th>
<th>Average turnaround time (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>100</td>
<td>3</td>
<td>16.5</td>
</tr>
<tr>
<td>Add-on patients</td>
<td>100</td>
<td>5.5</td>
<td>18.2</td>
</tr>
<tr>
<td>Add-on tests</td>
<td>100</td>
<td>6</td>
<td>19</td>
</tr>
<tr>
<td>Add-on emergency</td>
<td>100</td>
<td>7.5</td>
<td>20</td>
</tr>
</tbody>
</table>

Since the add-on emergency has the highest impact on workflow changes, an additional experiment was conducted to evaluate how the system reacts to an increase of emergency cases of 5% and 10%, respectively. Our findings are summarized in Table 4 and show that the situation is getting worse in terms of service levels (an increase in lateness ratio as the percentage of emergency cases increase).

Table 4: Impacts of the increase in emergency cases on MTP, lateness, and turnaround time

<table>
<thead>
<tr>
<th>Percentage of increase of emergency cases (%)</th>
<th>Lateness Ratio (%)</th>
<th>Average turnaround time (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7.5</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>21.5</td>
</tr>
<tr>
<td>10</td>
<td>17</td>
<td>23.5</td>
</tr>
</tbody>
</table>

The results in Table 3 and 4 show needs for a better redesign of processes involving the transfer of patients from a non CPOE unit to a CPOE unit, trauma and emergency cases, and an incomplete selection list of tests available in a CPOE system. For the latter, the study of the range of benefits that can be expected in the organization that invests in CPOE with a more complete selection list of tests.

5. Conclusion and future work

This work illustrates the use of simulation for evaluating and analyzing the impacts of workflow changes in healthcare resulting from the adoption and use of a computerized provider order entry. It is motivated by our longitudinal research program which aims to explore simulation modeling as one of the means that can be applied not only to contribute to an increased acceptance and use of CPOE systems, but also to assist in decision making. The setting used is The Ottawa Hospital, one of the Canada’s largest teaching hospitals, and its multi-phase, multi-year CPOE deployment project for laboratory and diagnostic imaging orders to improve both patient safety and quality of care. The preliminary results obtained show that the proposed simulation-based tool can be effectively used in its current level of development to quantitatively evaluate and compare different options of workflow changes within a given set of operational and organizational constraints, including policies, practices and procedures.

In addition to the scenarios described in this study, the proposed model will continue to be used in evaluating various workflow changes that fit within our modeling framework. Another research avenue will consist of extending the simulation model to include the laboratory processing of specimens and DI modalities. Finally, we seek to pursue research aiming to evaluate the extent to which exposure to the simulation model itself (through its graphical animation) and its findings (a) mitigate the barriers of end-users from non-CPOE units to accept and use the CPOE system; (b) is used to promote best practices and dissuade others; and (c) is contributing to reconcile the gap between workflows as planned versus workflows as enacted in practice.

References


consequences related to computerized provider order entry. *Journal of the American Medical Informatics Association* 13 (5) pp 547-556.


Figure 1: Overview of ordering workflows at TOH