Title of Case Study: Improved Rates of Venous Thromboembolism (VTE) Prophylaxis

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Executive Summary

Since 1968, North York General Hospital (NYGH) has served the culturally diverse communities of North Toronto with the best possible care experience. One of Canada’s leading community academic hospitals, we offer a wide range of acute, ambulatory and long-term care services across our three sites (inclusive of 618 inpatient beds) covering the south central region of Ontario, centered on Toronto (Figures 1 and 2). Our dedicated team of 5,000+ staff, physicians and volunteers are proud to serve a growing population of over 400,000 people. Our patients and their families are at the heart of everything we do.

NYGH has a history of adopting innovative technology to promote the ideal patient experience. Beginning in 2007, we embarked on a multi-year clinical transformation project to bring our electronic health record system (EHR) into the future, from HIMSS Stage 2 to a goal of HIMSS Stage 7. This project, called eCare, has a primary focus of improving the quality and safety of care that we provide to our patients every day. One of our first eCare initiatives was to improve the prevention of nosocomial Venous Thromboembolism (VTE). Prior to eCare, we pursued several paper-based VTE prophylaxis strategies, with only partial success.

NYGH’s VTE prophylaxis strategy took tremendous strides with the addition of evidence-based order modules and Computer Physician Order Entry (CPOE), both enabled by eCare. Combined, they propelled...
VTE prophylaxis rates to 84 percent. However, it wasn’t until targeted, real-time electronic alerts were embedded within the physician workflow that our rate jumped to 97 percent — and stayed there.

**Local Problem**

VTE, referring collectively to deep vein thrombosis (DVT) and pulmonary embolism (PE), is a serious complication that can arise in hospital inpatients, and is associated with increased patient mortality, length of stay and cost\(^1\). VTE prophylaxis is so important to safe inpatient care that it is a Required Organizational Practice identified by Accreditation Canada. To be accredited, Canadian hospitals need to demonstrate that inpatients at risk of VTE are provided with appropriate evidence-based thromboprophylaxis, and that a quality program is in place to measure and improve on prophylaxis rates over time.\(^2\)

Prior to eCare, NYGH pursued paper-based VTE prophylaxis strategies to comply with this accreditation requirement, with only partial success. In 2007, international VTE expert Dr. William Geerts\(^3\) conducted a study of several Toronto-area hospitals, including NYGH, to evaluate and compare rates of appropriate VTE prophylaxis. To our alarm, the study revealed that only 17 percent of patients received appropriate prophylaxis in our Medicine program (Figure 11). NYGH leadership swiftly introduced a rigorous physician education program and paper-based order set, which increased prophylaxis rates to 65 percent. However, these efforts were insufficient to sustain long-term improvement. By 2010, the paper order sets were no longer regularly used, which led to incorrect medications or doses being ordered for prophylaxis. Consequently, our appropriate prophylaxis rate dropped to 50 percent (Figure 11).

NYGH needed a programmatic, evidence-based strategy to successfully meet the challenge of sustainably improving our VTE prophylaxis rates. Our expectation was that by introducing health information technology to daily patient care via eCare, we could integrate orders for evidence-based VTE prophylaxis into physician workflow and improve our prophylaxis rates — which we did. But to achieve optimal compliance, we also had to introduce real-time clinical decision support to directly impact physician decision-making at the point of care.

**Design and Implementation**

The multi-year eCare project kicked off in 2007 across our three facilities. Implementation of the Cerner Millennium EHR occurred in two phases: Phase 1 launched in 2008 with interprofessional clinical documentation and enterprise-wide patient scheduling; two years later, Phase 2 introduced Computerized Provider Order Entry (CPOE), Closed Loop Medication Administration (CLMA), Medication Reconciliation, clinical decision support, and electronic discharge summaries with electronic discharge prescriptions.

\(\text{eCare} \) would not have been possible without a robust change management methodology, dedicated project management, transparent organizational communication and mandatory training. A Cerner project manager and NYGH project manager worked together to establish the project’s charter,

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governance structure and a detailed project plan. They facilitated weekly solution implementation and project management meetings to review progress against eCare milestones and timeline. A Change Management Workshop, Lean events and Failure Mode and Effects Analysis (FMEA) helped the entire project team understand the impact of new workflows and potential errors ahead of time.

Training of all staff and physicians in eCare clinical units was mandatory. Although eCare education incurred costs in terms of staff time, computer equipment and dedicated training rooms, it was essential to ensure the system could be used safely for patient care. Training facilities included dedicated classrooms with PC’s and demonstration monitors, as well as simulation rooms that allowed clinicians to work through typical patient care scenarios. The total cost of computer equipment for training, including 36 desktop computers, 16 demo monitors, and 26 CLMA devices was 65,000 Canadian dollars.

A total of 2293 staff were trained, including 730 nurses, 60 allied health/Pharmacy, and 209 physicians. Physicians were required to undergo 4 hours of training each, which could be completed entirely in-classroom, or partly online (remote computer-based training) with a follow-up in-person knowledge confirmation exercise. Nurses were required to complete 7.5 hours of in-class training, and could supplement knowledge by practicing scenarios in simulation rooms. Allied Health and Pharmacy professionals required between 2 and 4 hours of training each. Wherever possible, training course materials were designed around relevant clinical scenarios and workflows, rather than point-and-click tours of software functions and features. In total, 3355 hours of non-physician clinical staff time were required to complete training. Clinical units were required to backfill these training hours with additional staff, representing a significant cost that needed to be factored into the organization’s budget. Total physician training time was 836 hours. Physicians were not paid for their time, but were offered continuing medical education credits.

At system go-live, a dedicated team of Super Users was available to provide support (one per floor during every shift in 10-day increments). Physicians received at-the-elbow support from dedicated physician SuperUsers for their first shift, and had access to additional in-person and telephone-based help after that. Laminated memory aid cards, pocket-sized books and Intranet-based resources were also provided to all staff and physicians for reference. Together with IT staff, clinical informatics and NYGH leadership, 24x7 onsite support was provided for six weeks after go-live.

Thanks to the combined efforts of this community of stakeholders, both implementation phases were implemented on time and within budget. Additionally, in 2011 NYGH became the first community teaching hospital in Canada (and one of only three hospitals in Canada overall at that time) to achieve Stage 6 on the HIMSS Electronic Medical Record Adoption Model (EMRAM).

The successful implementation of eCare allowed us to enter a new phase of our VTE prophylaxis initiative. By 2010, using a paper-based approach, prophylaxis rates had declined by 15 percent, making it even more important to leverage the advantages of health information technology using eCare.

Beginning in April 2008, the eCare team began working with physicians to develop a library of electronic, evidence-based order modules for VTE prophylaxis, to be used with CPOE (Figure 3). Each VTE prophylaxis module was designed to be easy to use. Based on research from experts such as Dr. Greg Maynard at University of California, San Diego⁴, it became clear that physicians are most likely to

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effectively and frequently use a VTE prophylaxis decision algorithm if it is simple to understand and quick to use. It should include a straightforward method for VTE risk assessment, a list of appropriate prophylaxis options, and a list of contraindications to pharmacologic prophylaxis. In response to this evidence, NYGH developed a simple, standardized three-step VTE prophylaxis decision algorithm. This algorithm was linked into all VTE-related electronic order modules as a clickable evidence-based reference document. In tandem, the electronic order modules for VTE prophylaxis were constructed to display the same three steps as the algorithm, so that the CPOE order content mirrored the clinical decision support provided in the linked reference document (Figure 3).

Because the evidence for optimal prophylaxis is different depending on the patient population, unique VTE prevention modules were created specifically for Medicine (Figure 3), Critical Care, Orthopedic and General Surgery patients. For example, evidence-based content unique to orthopedic patients was incorporated into peri-operative orthopedic surgery VTE prophylaxis modules (e.g. options and timing for anticoagulant dosing for post-operative patients, including use of new oral anticoagulants – see Figure 4, left). In addition, a separate module for patients with stroke was created to incorporate detailed evidence unique to this patient population, such as specific contraindications to anticoagulant-based prophylaxis and risks of using graduated compression stockings (Figure 4, right).

The aforementioned VTE prophylaxis order modules were inserted into all applicable NYGH electronic hospital admission and peri-operative order sets (see example, Figure 3), with the goal of regular use by physicians. We were confident that this approach would increase our prophylaxis rates, since a previous Canadian study demonstrated that insertion of orders for VTE prophylaxis into hospital admission order sets improves prophylaxis rates\(^5\).

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Figure 3: NYGH electronic VTE prophylaxis schema

- Admission CPOE order set (top)
- Embedded evidence-based VTE prophylaxis module (lower left)
- Clickable 3-step evidence-based VTE prophylaxis algorithm, linked into VTE module (right)
How Health IT Was Utilized

The eCare team spent more than 2 years directly engaging its physicians and front-line clinical staff in the development of evidence-based order sets for use with CPOE, so that clinicians would embrace the system as their own. Physician champions regularly communicated why the organization was implementing CPOE – to improve quality and safety of patient care. In addition, in the weeks prior to go-live of eCare phase 2, NYGH delivered comprehensive education to train physicians how to complete their orders using CPOE. As a result, there was 100% physician adoption of eCare and CPOE in the first week of conversion. Furthermore, there was evidence of a culture change; physicians responded to CPOE use by fully engaging in the use of standardized order sets. This was demonstrated by a retrospective chart review of Medicine inpatients before and after CPOE implementation. There was an increase in order set usage by physicians on admission to hospital, from approximately 36 percent of patient volume to over 97 percent of patient volume. Accordingly, since evidence-based VTE prophylaxis modules were built into all admission order sets, chart audits revealed that appropriate VTE prophylaxis rates for medical inpatients increased from 50 percent of patient volume (in 2010, pre-eCare) to 84 percent of patient volume (November 2010, post eCare conversion) (Figure 11). These remarkable improvements were all realized without making CPOE or VTE prophylaxis mandatory.
Still, NYGH aimed even higher. CPOE alone was not enough to ensure industry-leading VTE prophylaxis rates. Per research from Dr. Greg Maynard at UC San Diego\(^6\), there is a “Hierarchy of Reliability” whereby organizations that implement an easy-to-follow algorithm for provision of VTE prophylaxis, and then integrate it into point of care orders, should expect to achieve a rate of appropriate VTE prophylaxis between 65 and 85%. To achieve higher prophylaxis rates (e.g. over 95%), the Hierarchy indicates that real-time electronic clinical decision support is required (Figure 5).

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<td>No intervention – no VTE protocol</td>
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<tr>
<td>Simple-to-follow VTE protocol, paper (3-level risk stratification, not score-based)</td>
<td>50%</td>
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<tr>
<td>Standardized, evidence-based VTE order module, embedded into CPOE order sets</td>
<td>65-85%</td>
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<td>Real-time electronic clinical decision support</td>
<td>95%+</td>
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Figure 5 – VTE Prophylaxis Hierarchy of Reliability

Initially, NYGH decided not to turn on automated clinical decision support for VTE prophylaxis, out of concern that it would overwhelm the physicians during the initial adoption period post-eCare conversion. However, once we learned that VTE prophylaxis rates could jump above 95 percent with automated, real-time interventions, we changed our approach – but not without seeking the involvement and input of our physicians first.

Early in 2011, the NYGH eCare Team analyzed the workflow physicians were following to enter electronic orders with CPOE. They worked closely with a group of physicians to understand where in their workflow it would make sense to embed automated alerts to meaningfully influence decision making. Together, they agreed on an approach that would briefly interrupt the physician workflow at the appropriate time to assess VTE risk, and prompt immediate action if required.

After completing this work, NYGH introduced an automated clinical decision support rule that reminds physicians to order (or consider) VTE prophylaxis if they happen to forget to address it during the admission or post-operative ordering process (Figure 6). To minimize alert fatigue and maximize response to the alert, we carefully designed the alert to fire only if all of the following are true:

- The attending (most responsible) physician is opening the electronic chart
- VTE prophylaxis (pharmacologic or mechanical) has not yet been ordered for the current hospital admission
- There is an absence of a specific electronic physician order on the chart, which indicates that VTE prophylaxis has been considered for the current hospital admission, but is not necessary for the particular patient (e.g. because the patient is fully mobile, or has an anticipated short stay of under 48 hours). This order is called: “VTE Prophylaxis Not Indicated”. The order is embedded in VTE prophylaxis modules inserted into admission and post-operative order sets, as well as available from the CPOE order catalogue and the alert.

To further increase the clinical utility of the alert and build decision support into the physician workflow, we incorporated access to the evidence-based VTE prophylaxis modules and related orders directly into the alert window. This allowed physicians to respond to the alert as soon as they saw it, rather than having to close the alert window, navigate to the orders screen and find the appropriate orders (which would have decreased efficiency and increased the likelihood that physicians would get distracted and forget to order the items required to respond to the alert).

In 2012, after the VTE prophylaxis alert was introduced, an NYGH quality audit was undertaken using a standardized chart review tool. The results proved Maynard’s prediction. Appropriate VTE prophylaxis rates for medical inpatients at NYGH had increased from 84 percent (in 2011) to 96 percent (in 2012) (see Figure 11). To enhance data quality for future audits, a list of coded reasons for no prophylaxis was added to the “VTE Prophylaxis Not Indicated” order (see Figure 7).

In April 2013, as part of a national VTE prevention improvement program, we audited our VTE prophylaxis data once again. We discovered that most physicians were not selecting any of the provided reasons when they entered the “VTE Prophylaxis Not Indicated” order. In partnership with front-line physicians, we reviewed the VTE prophylaxis ordering workflow and CDS content. Based on physician feedback, the “VTE Prophylaxis Not Indicated” reason list was adjusted for clarity. In addition, physicians agreed that it would be reasonable to make the reason list mandatory, so that data quality and patient safety could be enhanced. A hard stop was introduced, which prevented physicians from entering a “VTE Prophylaxis Not Indicated” order without providing a reason. This change also meant that the VTE prophylaxis alert would keep firing until a form of prophylaxis was ordered, or a “no prophylaxis” reason was provided.
One year later, in 2014, we analyzed the effect of making the “VTE Prophylaxis Not Indicated” reasons mandatory. We discovered that in specific scenarios, such as when the reasons "Invasive Procedure Planned in less than 24 hours", or "Anticipated remaining length of stay less than 48 hours" were entered, the alert behaved sub optimally (see circled items in Figure 7). Because the “VTE Prophylaxis Not Indicated” order persisted on the chart for the patient’s entire hospital admission, the order would inappropriately suppress a repeat VTE Prophylaxis alert if the reason for no prophylaxis was time-limited and no longer applicable, such as when an invasive procedure had already been completed, or the patient’s stay was unintentionally prolonged for greater than 48 hours. To correct this issue, we further modified the alert code so that if the time window for a given “VTE Prophylaxis Not Indicated” reason had elapsed, the previous “Not Indicated” order would be removed. This allowed the VTE Prophylaxis alert to fire once again (Figure 6), preventing physicians from accidentally forgetting to reconsider prophylaxis once a specific scenario not requiring prophylaxis was no longer applicable. The modifications undertaken in 2013 and 2014 were particularly helpful to improve automated VTE prophylaxis guidance in peri-operative and peri-procedural scenarios, where pharmacologic prophylaxis is often withheld prior to an invasive procedure or surgery, but should be started again soon afterward.

In addition to iteratively improving dynamic CDS (alerts), another important component of our strategy for increasing rates of appropriate VTE prophylaxis was to continually review and update the static CDS (evidence-based guidance) in the CPOE order modules. Figure 8 illustrates the timeline for creating and updating each of the patient population-specific VTE prophylaxis order modules. NYGH utilized Zynx Health’s ZynxOrder product to assist this process, in four ways: 1) evidence-based order sets in Zynx’s order set library were used as a starting point to create prototype NYGH VTE prophylaxis order modules, which were then further customized to our organization by modifying content and adding references; 2) regular content updates from Zynx helped our team to keep the evidence-based information in our order modules up-to-date; 3) ZynxOrder has software tools that automate processes such as order set editing, electronic transmission of order sets for review by multiple clinician groups, logging of comments from clinical reviewers, and order set versioning; 4) ZynxOrder has two-way integration with our Cerner EHR, allowing us to seamlessly import and export order set content, and build in Zynx using our native Cerner order catalogue. Figure 4 depicts examples of NYGH VTE prophylaxis order modules customized using the ZynxOrder AuthorSpace tool. The Zynx software dynamically updates icons within the tool that indicate when new clinical evidence becomes available.
Our quality improvement approach focused on regular audits of VTE prophylaxis rates, clinical workflow, system design, and published evidence, which in turn allowed us to identify how our electronic CDS could be iteratively improved. Quality audits for VTE prophylaxis were prompted by the Hospital Quality of Care Committee (in response to the organization’s Quality Improvement Plan), as well as the CMIO, and by nationwide patient safety improvement programs. Audits were conducted by NYGH Clinical Informatics and Decision Support staff, and results were shared throughout the Quality Governance Structure at NYGH (Figure 9, left). Each audit required partially manual (but standardized) review of electronic charts by experienced staff, because the determination as to whether VTE prophylaxis was appropriate was multifactorial. Consequently, rates of appropriate VTE prophylaxis could not be fully automated for inclusion into reporting by the NYGH Business Intelligence (BI) system. Nosocomial VTE incidence rates, by contrast, were automated using queries from the BI system (see Value Derived section, below).

Using the DMAIC quality improvement structure (Figure 9, right), Clinical Informatics and Quality Improvement staff worked in partnership with front-line clinicians to identify opportunities to improve VTE prophylaxis-related CDS content and ordering workflow. The interprofessional eCare order set team regularly refreshed VTE prophylaxis order module content to reflect updates to published evidence and the hospital formulary (Figure 8), and these updates were reviewed and approved by physicians and the Medical Affairs Committee. Before release to front-line physicians, all updates to CDS content were tested by Clinical Informatics, the CMIO and Physician Champions. Updates to VTE real-time alerts were initially tested using a special “stealth mode” where alert events in a live clinical environment did not fire to users, but were logged in the background. This allowed adjustment of alert sensitivity and specificity prior to release for actual clinical use. All details of updates to CDS content were shared in emails to physicians, in department meetings as well as posted on a physician-specific portal on our organization’s Intranet site (Figure 10).

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Figure 8 – Timeline for VTE Prophylaxis Order Module Evidence Updates at NYGH
Quality Governance Structure

Figure 9 – Quality Governance Structure (left), and DMAIC Structure (right) utilized for implementing quality improvement at NYGH

Figure 10 – Example of communication to physicians regarding VTE prophylaxis CDS updates

eCare Update – DVT / VTE Prophylaxis
May 2013

The DVT/VTE Prophylaxis OrderSets and Alerts have recently been updated with the most recent recommendations from Chest Guidelines 2012, Canadian Safety Patient Institute, American Society of Regional Anesthesia and Central Nerve Block.

We now have 7 VTE Prophylaxis Order Sets. The most important changes are as follows:

1. Two new pre-op VTE prophylaxis modules. As before, VTE Prophylaxis Modules are named based on patient groups, and now include Medicine, Surgery (group and postop), Ortho (group and postop), GCO and Stroke patients.

2. Low molecular weight heparin for VTE Prophylaxis in patients with renal impairment. We have updated the wording of reminders regarding "renal impairment" and "extreme of weight" to make them clearer.

3. Added links to Pauzus and Carperin Risk Assessment Models (see screenshots in Appendix, page 3)
   a. Pauzus Score Risk Assessment Model to assess VTE risk in medical inpatients when the VTE risk is unclear.
   b. Carperin Score Calculator to assess VTE risk in surgical inpatients when the VTE risk is unclear.

4. A drop-down menu has been added on the "VTE Prophylaxis Not Indicated" order which will be used for indicating the reason for not using thromboprophylaxis. This will be used for quality improvement purposes.

5. Updated VTE Prophylaxis section in the "Hip Fracture Pro-Operative Medicine Consult Orders (Adult) (Modular)" OrderSet.

6. Updated evidence link on anticoagulants used in orthopedic patients for VTE prophylaxis.

7. Updated timing of preop and postop VTE prophylaxis in Surgical and Orthopedic Patients.

To Access Risk Model:
Point mouse to these icons on the PowerPlugs+ Then click this link →

Does this Patient Require VTE Prophylaxis?
The patient has no orders as the chart regarding prevention of Venous Thromboembolism (VTE). Please update the patient’s risk factors, and order either:

1. Does the VTE Prophylaxis PowerPlugs ordered below
   a. OR
   b. VTE Prophylaxis Not Indicated order.

2. Click the "More Info" button for VTE Prophylaxis Guidelines.

If Patient WAS ACTIVE BLEEDING: Please remember to order mechanical prophylaxis (TEDs or Sequential Compression Devices)
These ongoing quality improvement efforts proved to be very much worthwhile. Not only were VTE prophylaxis rates maintained year after year, they were further improved. A repeat chart audit at NYGH in 2016 revealed that our medical inpatient VTE prophylaxis rate had climbed to 97 percent (Figure 11).

Value Derived

The combined efforts of our physicians and clinical informatics team, along with the real-time capabilities enabled by eCare, raised the rate of appropriate VTE prophylaxis in our medical patients by 80 percent since the launch of this initiative in 2007 (Figure 11). Implementing CPOE was a crucial step in our transition from the previous paper-based quality intervention. However, it wasn't until real-time alerting and decision support was incorporated into the physician workflow that performance exceeded 95 percent.

What is perhaps most remarkable is that NYGH has sustained appropriate prophylaxis rates of over 95 percent for the past four years. As illustrated by the drop in VTE prophylaxis at NYGH by 15 percent between 2007 and 2010 despite implementing a paper-based quality improvement program, it is clear that sustaining improvements in quality is a unique challenge for hospitals. However, health information technology provides a unique advantage in that evidence-based quality improvements, if carefully designed, can be built into standard clinical workflows that persist over time because they are integrated into system design and use. It is this advantage that we believe allowed us to maintain and even improve our already high VTE prophylaxis rates over the past four years.

Today, 97 percent of NYGH medical inpatients consistently receive appropriate VTE prophylaxis (Figure 11). Our success proves the superior efficacy and longevity of automated interventions within the physician workflow. More importantly, we realized improved clinical outcomes along the way.

Figure 11 – Rates of Appropriate VTE Prophylaxis in Medical Inpatients at NYGH, 2007 to 2016
As part of eCare implementation, NYGH took advantage of the vast new store of discrete clinical data being generated. Our organization implemented a business intelligence (BI) system to enable automated reporting of key performance indicators as well as enable rapid query-based reports on clinical outcomes. VTE prophylaxis is one of NYGH’s quality improvement foci. Incidence rates for VTE (including deep venous thrombosis [DVT], pulmonary embolism [PE], and combined cases [DVT+PE]) are tracked each fiscal year, using automated query-based reports from our BI system. Depicted in Figure 12 is a quality report that enumerates the incidence of nosocomial VTE (DVT, PE) among NYGH medical inpatients each fiscal year. The denominator is the population of discharged medical inpatients in the same fiscal year, allowing calculation of a percentage VTE rate, as well as a rate per 1,000 admissions. In this report, community-acquired VTE cases are excluded. It is also important to note that a given inpatient may be diagnosed with both DVT and PE, in which case they are counted twice in this report (once in the DVT row, and once in the PE row).

- **DVT**
  - **Rate per 1k Admissions:** 0.000% (FY16/17), 0.035% (FY17/18), 0.164% (FY18/19), 0.124% (FY19/20), 0.021% (FY20/21), 0.129% (FY21/22), 0.128% (FY22/23), 0.130% (FY23/24), 0.213% (FY24/25)

- **PE**
  - **Rate per 1k Admissions:** 0.000% (FY16/17), 0.035% (FY17/18), 0.060% (FY18/19), 0.046% (FY19/20), 0.081% (FY20/21), 0.076% (FY21/22), 0.069% (FY22/23), 0.114% (FY23/24)

- **Overall VTE**
  - **Rate per 1k Admissions:** 0.000% (FY16/17), 0.080% (FY17/18), 0.157% (FY18/19), 0.058% (FY19/20), 0.176% (FY20/21), 0.185% (FY21/22), 0.083% (FY22/23), 0.313% (FY23/24)

For analysis purposes, the report can be divided into pre-eCare outcomes and post-eCare outcomes. eCare was implemented toward the end of fiscal year 2010/2011; all data from this fiscal year and earlier are categorized as pre-eCare, whereas all data from fiscal year 2011/2012 and later are categorized as post-eCare. The data, expressed as VTE rate per 1,000 admissions, is depicted graphically in Figure 13, and in a tabular format in Figure 14. Our reporting demonstrates an improvement in the post-eCare VTE rate when compared to pre-eCare (Figures 13 and 14). The VTE incidence rate declined from 51 out of 22,214 admissions pre-eCare, to 62 out of 44,279 admissions post-eCare. In other words, the pre-eCare rate of 2.3 VTE cases per 1,000 admissions dropped to 1.4 VTE cases per 1,000 admissions after eCare was implemented. In this calculation, please note that to obtain an overall VTE incidence rate per admission, separate diagnoses of DVT and PE in the same patient were counted only once (since both DVT and PE are almost always concomitant when diagnosed together, and collectively both conditions are referred to as VTE).

To calculate the number of VTE cases potentially prevented since the implementation of eCare, the calculated pre-eCare VTE incidence rate was applied to the post-eCare medical inpatient volume (Figure 14). This resulted in an expected VTE rate of 102 cases between fiscal 11/12 and fiscal 15/16 inclusive. However, only 62 cases were actually observed over this time period. This demonstrated a total of 40 VTE cases prevented.
This improvement does not reach statistical significance. We think this is for two reasons. First, our baseline pre-eCare VTE incidence rate was already quite low in the context of overall patient volume. Second, research indicates that the majority (58%) of hospital-acquired VTE cases are diagnosed not during the causative hospital stay, but rather on readmission due to post-discharge symptoms. In our case study, we were not able to include and analyze patients admitted with VTE from the community, because it was not possible to manually confirm whether these patients had a recent causative hospital stay at NYGH, or at a different hospital. Including these patients in our analysis would have made our results inaccurate, since not all patients admitted from the community with VTE would have been recently treated at our hospital.

Regardless, we are thrilled with the outcome of this initiative. Our reporting reveals that since implementation of eCare, in addition to increasing our appropriate VTE prophylaxis rate to 97%, we prevented approximately 40 VTE cases, inclusive of averted DVTs, PEs and DVT+PEs (Figure 14). This represents a calculated VTE incidence reduction rate of 39.2%.

We encourage other health care organizations to pursue similar efforts, even if their baseline VTE rate is low in the first place. Our experience demonstrates that with the help of a well-designed and adopted advanced electronic health record system, clinicians can deliver exemplary evidence-based care that is best for patients. Furthermore, such a system can ingrain best practice into standard workflow, resulting in quality improvements that are sustainable year after year. These improvements can also lead to considerable cost savings, through the prevention of adverse events. Savings that NYGH realized because of improvements in VTE prophylaxis are detailed in the Financial Considerations section of this case study.

Lessons Learned

Physician engagement and buy-in are essential to success: NYGH directly involved a team of physicians from the very beginning of this initiative. Without their buy-in and input, the evolution of our VTE prophylaxis modules – not to mention the real-time alerts – would not have been impactful nor successful in guiding physicians to adopt evidence-based prophylaxis. Physician engagement is invaluable to the build and adoption of new technology to guide best practices, as well as its continued improvement.

Paper-based order sets are insufficient to sustainably improve VTE prophylaxis rates: When Dr. Geerts’ 2007 study revealed that only 17 percent of our medical inpatients received appropriate VTE prophylaxis, NYGH leadership swiftly introduced a rigorous physician education program and paper-based order set. This step increased prophylaxis rates to 65 percent, but only temporarily. By 2010, the paper order sets were no longer regularly used and our percentage dropped to 50 percent. To make sustainable improvements, NYGH needed a programmatic strategy that built evidence-based care into standard workflow.

Although a crucial step, CPOE alone is not enough to ensure optimal performance: Initially, the eCare team worked with physicians to develop evidence-based order modules for VTE prophylaxis. They were designed to be compatible with CPOE, and were built into physician workflow by including them in all admission and post-operative order sets. Physicians also received comprehensive training on use of CPOE for order entry before system go-live. Chart audits revealed that physician adoption of CPOE and the order modules substantially increased the VTE prophylaxis rate from 50 percent to 84 percent, without making these processes mandatory. Still, these efforts were insufficient to increase prophylaxis rates further. To achieve optimal performance, we had to directly impact physician decision-making at the point of care by using real-time clinical decision support.

Careful design of real-time clinical decision support propelled appropriate prophylaxis rates above 95 percent: Together with a group of physicians, the eCare team collaborated on the design of a real-time electronic clinical decision support alert that would interrupt the physician workflow at the appropriate time, to prompt assessment of VTE risk. The alert reminds physicians to order VTE prophylaxis in the appropriate patients, if they happen to forget during the admission or post-operative ordering process.
Access to evidence-based VTE prophylaxis modules was integrated directly into the alert window, making it very easy and fast for physicians to respond to the alert appropriately. We also managed alert fatigue by carefully designing the alert to fire only under very specific circumstances. By 2012, we proved Dr. Maynard’s theory: real-time decision support increased appropriate VTE prophylaxis rates at NYGH to 96 percent of medical inpatient volume.

Regularly-scheduled quality audits and iterative system improvements yielded continued success: NYGH continued to improve upon VTE prophylaxis rates by regularly auditing local VTE outcome data and identifying opportunities for further system redesign and workflow enhancements. This iterative improvement process identified the potential benefit of introducing mandatory coded reasons for no prophylaxis in the “VTE Prophylaxis Not Indicated” order. Later, based on subsequent quality audits, we identified further potential benefit by revising the alert to behave differently if a "VTE Prophylaxis Not Indicated" order was entered in the chart for a specific time-sensitive reason such as, "Invasive procedure planned in under 24 hours," or "Anticipated remaining length of stay under 48 hours". The alert was modified to re-fire as soon as any of these time-limited reasons expire, so that it would once again prompt physicians to consider ordering VTE prophylaxis. As a result of these improvements, our VTE prophylaxis rate climbed even higher, to 97 percent.

Continuously measure progress to identify roadblocks, facilitate learning and recognize iterative improvement: With the institution of eCare, NYGH capitalized on the wealth of discrete clinical data that became available to the organization by implementing a business intelligence system, making it possible to conduct rapid queries to assess clinical outcomes (such as incidence of VTE). As part of strategically-aligned corporate quality improvement programs, rates of appropriate VTE prophylaxis and VTE incidence were regularly audited. Through an established quality governance structure and quality improvement framework, opportunities for improvement were identified and actuated in partnership with front-line physicians. With each iterative improvement step – from the decision to implement CPOE, to the development of evidence-based VTE prophylaxis order modules, to real-time clinical decision support – our VTE prophylaxis rates have continued to climb. NYGH will continue to leverage discrete clinical data and business intelligence-based reporting to unveil new opportunities for improvement – both in VTE prophylaxis and in the prevention of other adverse nosocomial events.

Empowering the Canadian healthcare community: The CPOE Toolkit

NYGH has come a long way since the launch of eCare in 2007. We have achieved exemplary outcomes thanks to a community of stakeholders who are embracing new IT-enabled processes to deliver care to our patients. Even with considerable changes to healthcare funding and care delivery in our province over the past several years, our efforts remain centered around one mission: Our Patients Come First in Everything We Do.

We recognized that while CPOE systems can deliver substantial clinical benefits, success is certainly not guaranteed. CPOE implementation is difficult, expensive, and can result in failure to achieve clinician adoption and positive patient outcomes. In Canada, we have a non-competitive, publically-administered and funded healthcare system. At NYGH, we felt compelled to share our best practices and lessons learned, to assist other organizations in the implementation of CPOE. Through sharing, we hoped to reduce the cost and time required for CPOE implementations across the country. Equally important, we wanted to ensure that clinician engagement and clinical practice transformation became central goals of each CPOE project, to produce high rates of system adoption and positive patient outcomes.
We approached *Canada Health Infoway* with an idea to create a national toolkit to share content and lessons learned, at no cost, with other hospitals. We successfully won a competitive bid to receive funding for this project, which is called the **Canadian CPOE Toolkit** (Figure 15). The Toolkit is a robust online resource that includes a 400+ page implementation guide and a searchable library of evidence-based order sets. It is based on a multi-publisher sharing model that allows contributing organizations to share their content at no cost (while retaining full ownership of their contributions).

The Canadian CPOE Toolkit continues to expand as NYGH refines its own order sets, and as contributing organizations share their findings. Today, there are 57 member organizations, six contributing organizations and 473 active users from CPOE implementation teams across seven Canadian provinces. Each organization has access to more than 1,500 evidence-based electronic order sets that they can localize to their own clinical workflows in partnership with their clinicians, and then build into their own CPOE systems. The Toolkit is accessible via this web address: [http://www.cpoe-toolkit.ca](http://www.cpoe-toolkit.ca).
Financial Considerations

The total cost of the multi-year eCare investment since 2010 is $36.9 million CDN; it consists of $13.9 million in capital expenditure and $4.6 million in annual operational costs. A more thorough breakdown of the total cost of ownership for eCare, inclusive of planned costs, is detailed in Figure 16.

**Initial Capital costs**
- eCare project costs: $12.8 million
- Hardware/Infrastructure: $1.1 million
- Total: $13.9 million

**Ongoing operational costs (per year)**
- Software/Hardware: $1.9 million
- IT and CI Staff: $2.7 million
- 5-Year Total: $23 million

**Total eCare investment from 2010 – 2015:**
$36.9 million

NYGH did not measure a statistically significant drop in the overall nosocomial VTE incidence rate since the launch of eCare, in large part due to the fact that the VTE incidence rate was not high at NYGH to begin with. However, in spite of a low baseline, we managed to reduce our nosocomial VTE incidence rate by 39%, from 2.3 to 1.4 cases per 1,000 admissions. This improvement also yielded considerable cost savings.

A July 2012 report by the Canadian Patient Safety Institute (CPSI)\(^8\) reviewed the per-case costs of DVT, PE and DVT+PE. As indicated in the Value Derived section of this case study, NYGH prevented 40 cases of VTE since the inception of eCare (refer to Figures 12, 13 and 14). When considering these industry costs, NYGH has realized a cost savings of **more than one million dollars** so far (Figure 17) – proving that even a small improvement can yield a significant financial benefit.

Please note that in Figure 17, we are counting the total number of patients pre-eCare that had any VTE event. Because our original data set counts DVT and PE separately even if they occur in the same patient, it was necessary to subtract the number of combined DVT+PE cases (3) from the total number of individually counted DVT cases and PE cases (54) to arrive at the correct number of patients with any VTE event (51).

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In addition to reducing costs by preventing VTE, the eCare project has realized substantial savings by preventing several other common and costly adverse inpatient events. Examples of these cost savings are outlined in our other three case studies. A comprehensive framework of the total eCare return on investment (ROI) is detailed in the Financial Considerations section of our case study that focuses on reduction of preventable inpatient deaths. Please refer to that case study for more details.

Moving forward, North York General Hospital will continue to use eCare to design and iteratively improve IT-enabled, patient centered solutions that achieve the best clinical and financial outcomes for our patients, families, community and health care system. We will also continue to share our lessons learned with other organizations, so that they can achieve similar benefits.