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Improvement of Stroke Alerting Process Utilizing Haiku, an EHR Based Alerting System

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Improvement of Stroke Alerting Process Utilizing Haiku, an EHR Based Alerting System

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Dedication

I dedicate this work to the strong nurses in my life who have inspired me throughout my career and continue to motivate me daily.

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Abstract

Acute ischemic stroke is the interruption of blood flow to the brain. Each minute of ischemia causes the death of 1.9 million neurons, making treatment for acute ischemic stroke exceedingly time sensitive. Treatment decisions require complex imaging and evaluation. Specialized teams including Neurologists, pharmacists and CT technicians are alerted to the ED when a patient presents with signs or symptoms of acute ischemic stroke to carry out these evaluations. In the Hospital of the University of Pennsylvania ED, these alerts were delivered via a de-identified text message, preventing the collection of data needed for clinical effectiveness and quality improvement work. The purpose of this project was to improve the Stroke Alert process using Computerized Physician Order Entry (CPOE) to initiate the alert via a HIPAA Compliant Group Messaging (HCGM) application called Haiku. Haiku is an application available in Penn Chart, the hospital's electronic health record, which allows for retrieval of data unavailable when utilizing the de-identified alerting method. Data on Stroke Alert volumes from 6 weeks prior to implementation of the Haiku Stroke Alert was compared to volumes 6 weeks after implementation. A comparison of Door to CT and Door to Needle times in those periods were also compared to ensure the new process did not cause any delays in these metrics. Results showed the CPOE based Haiku Stroke Alert process was easily adopted, and allowed for access to data necessary for clinical effectiveness and quality improvement work without causing delays in Door to CT or Door to Needle times.

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Chapter 1: Introduction

Treatment for acute ischemic stroke (AIS) is exquisitely time sensitive. Every minute of continued ischemia causes a loss of 1.9 million neurons, leading to the mantra of “time is brain” (Saver, 2005, p. 263). When patients present to the Emergency Department (ED) with signs or symptoms of AIS, a series of hyperacute assessments need to be completed to determine appropriate treatment. In this setting, hyperacute refers to the time from patient presentation in the ED until treatment decision. Assessment of airway, breathing and circulation is the first step in emergency triage, and a last known well (LKW) time needs to be established. A CT scan of the brain is vital to determine whether the stroke is ischemic or hemorrhagic. Further imaging, including a CT angiogram, to identify the presence of an occlusion in a blood vessel in the brain, and CT perfusion to determine the extent of permanent damage, must be completed. Lab work may be required if the patient takes medications that impact coagulation, intravenous lines must be placed, an accurate neurological exam must be completed, and finally, a treatment decision needs to be made and delivered. The complexity and number of tasks to be completed requires a team of trained healthcare professionals which includes neurologists, nurses, CT technicians and pharmacists. In order to bring these vital team members to the bedside, a “Stroke Alert” is issued. Currently, at the Hospital of the University of Pennsylvania (HUP), the Stroke Alert is delivered by the Unit Secretary, who is verbally instructed to activate the alert. It is activated by clicking a link on the Penn Medicine Intranet which triggers a text message to preprogrammed phone or pager numbers.

The current process utilizes unprotected devices and exists outside the HUP electronic health record (EHR), PennChart. These factors present significant challenges to the collection of data which is necessary to improve stroke care in the ED. Since this alert is delivered as a text message to unprotected devices, there is no patient identifying information contained in the alert. The alert simply makes the team aware they need to mobilize to the ED for a stroke patient however, there is no link or consistent notation in the patient record that a Stroke Alert was initiated. PennChart has the capacity to build automated data reports. Tracking the proper use of patient order sets and documentation of provision of appropriate patient education are two examples of the types of data these reports can deliver. As the current alerting process has no linkage to PennChart, Stroke Alerts cannot be tracked via these automated reports. Adding the de-identified nature of these alerts to the lack of linkage to PennChart makes any data collection outside a raw count of alerts impossible. For patients with a discharge diagnosis of AIS, it is possible to try to match the alert by comparing text alerts to ED arrival time, but this is a time-consuming process. Unfortunately, for patients who are Stroke Alerted but are not ultimately diagnosed with AIS, there is no way to track any data. This is not an insignificant number of patients presenting to the HUP ED, although this fact is anecdotal from feedback of the responding team as the data on outcomes of all stroke alerts is unavailable. For the reasons identified, it is essential that this process work in an efficient and timely manner every time it is used. The current process makes data collection on every alert impossible. The lack of patient identifying information presents a significant barrier to the collection of data for quality improvement.

The American Heart Association (AHA) recognizes the vital importance of data collection in the improvement of stroke treatment delivery. Nationally recognized guidelines for the early management of AIS patients issued by the AHA include recommended time intervals that should be tracked to lead to faster treatment (Powers et al., 2019). These guidelines inform a voluntary national registry called Get With the Guidelines (GWTG) which collects data on hospitals' adherence to the guidelines (Ormseth et al., 2017). All time intervals begin with patient arrival in the ED, or “door time”. The important time metrics include response time of the team from alert, door time to head CT (DTCT) and door time to thrombolytic treatment (Door to Needle - DTN) (Powers et al., 2019). These time metrics represent pieces of the puzzle that make up the hyper-acute assessment period. Impacting any of these intervals will speed the time to treatment, ultimately reducing the number of neurons lost. Hospital teams, led by the Stroke Coordinator, track these metrics to improve processes.

The obvious clinical inquiry that makes this project necessary: is there a way to initiate the Stroke Alert that utilizes protected communication and harnesses the power of PennChart to gain access to data that is currently unavailable? This project looks to initiate the Stroke Alert via an order in PennChart, which would then communicate the alert via an HIPPA Compliant Group Messaging (HCGM) application called Haiku that is integrated within PennChart. The use of computerized physician order entry (CPOE) to improve time to treatment for stroke patients has been well recognized (Cho et al., 2014). Pourmand et al. (2018) confirmed in their review of literature on the use of secure smartphone applications in emergency departments, the value of HCGM apps in streamlining communication of stroke alerts to the appropriate teams.

At HUP, the Acute Hip Fracture team exists to emergently evaluate patients for hip fracture in the ED in an effort to speed operative repair. This team has successfully utilized a PennChart order-based alert, via Haiku, to mobilize their team. Based on contemporary experience of similar medical treatment teams at HUP, transitioning the Stroke Alert process to a PennChart based Haiku alert is an ideal way to allow for enhanced data collection for every time a Stroke Alert is issued. To ensure this manner of alerting is not inferior to the current process, Stroke Alerts using the new process will be tracked for a 6-week period and compared to Stroke

Alerts issued 6 weeks prior to initiation of the new process. The data will be compared to show that the new process does not lengthen and may reduce DTCT and DTN times.

Implementing this process will allow for the availability of data on all Stroke alerts which will inform ongoing quality improvement work. In the most recent scientific statement updating their recommendation for care of the AIS patient, the AHA recognizes the vital nature of data to improvement of care; recommending “well-designed electronic health record platforms...capable of automating data collection, and electronically reporting quality metrics” (Ashcraft et al., 2021, p. e12). With this new process, it will be possible for the first time to track important metrics of all Stroke Alerts beyond just a raw count, to include door to alert and DTCT times, as well as outcomes. Easy access to this data will provide a more robust picture of the current process, identifying opportunities for improvement of patient care. Harnessing the power of this data will lead to the ultimate goal of hastening treatment decisions to save more neurons since “time is brain”!

Chapter 2: Literature Review

This literature review includes a review of the relevant literature concerning the triage process for AIS in the ED, with a more specific focus on the earliest part of this process: initiating the stroke alert. The stroke alert begins the “hyper-acute” phase of triage which for the purposes of this project includes the time from alert to treatment decision. This review is divided into the following sections: epidemiology of AIS, use of computerized physician order entry (CPOE) in stroke alerting, use of HIPAA compliant group messaging (HCGM) applications in the stroke alert process and review of the theoretical framework for this project.

English language articles regarding the stroke alerting process in the ED for AIS patients were reviewed. CINAHL and PUBMED were searched for research studies regarding the stroke alerting process. The literature review covered 2015 to present, as research on the efficacy of mechanical thrombectomy for AIS changed established treatment guidelines for in 2015, yielding 262 results. Also included were four seminal works prior to 2015 to provide important background to this current project.

Inclusion criteria were studies that included the initial steps of the stroke alerting process, and that described use of CPOE and/or HCGM. Excluded were those studies that did not define the method of alerting teams to an AIS patient. Many studies focused on the process once the team responded rather than on the manner the alert was delivered. As this project is focused solely on the improvement of the alert itself, most studies in the initial search were excluded. The studies that were selected after applying the selection criteria include six quantitative studies, one qualitative, two reviews of literature, one meta-analysis, and one review article which described the use of mobile device applications.

Epidemiology of AIS

AIS is caused by an obstruction preventing blood flow to the brain resulting in the death of the area of the brain affected. According to the AHA, about 795,000 people suffer a new or recurrent stroke each year, with 87% of those being ischemic stroke (American Heart Association Council on Epidemiology and Prevention Statistics Committee and Stroke Statistics Subcommittee [AHA], 2020). With a stroke reported in the US every 40 seconds, this represents a significant challenge to the health care systems and to ED's in particular. The specific challenge is the exquisitely time sensitive nature of available treatments. Saver (2005) quantified a loss of 1.9 million neurons for every minute of ischemia, resulting in an equivalent of aging the brain by 3.6 years for every hour a stroke is left untreated. Treatments, therefore, aim to restore blood flow as quickly as possible. The thrombolytic, alteplase, was first proven effective for AIS in 1995, but only if administered in the first 3 hours from stroke onset (The National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group [NINDS], 1995). Further research by the European Cooperative Acute Stroke Study (ECASS) group (Hacke, 2008) allowed for expansion of that window to 4 ½ hours in selected cases. In 2015, thrombectomy, where the occlusion is mechanically removed utilizing a specialized device called a stent retriever, was demonstrated to be effective up to 6 hours from stroke onset (Saver et al., 2016). Additional research extended that window to 24 hours in patients with favorable imaging (DAWN Trial Investigators [DAWN], 2018). While these treatments have revolutionized stroke care, they have also introduced complexities to the triage of the emergency patient presenting with stroke symptoms. Alteplase requires that patients meet very specific inclusion and exclusion criteria. Thrombectomy requires specialized imaging to demonstrate the ratio of irrevocably infarcted brain (core) to the brain tissue at risk (penumbra).

The AHA has recognized these complexities, leading them to issue a series of advisories, scientific statements and guidelines to assist health systems to meet the needs of AIS patients. In 2010, an AHA Presidential Advisory recommended the establishment of certified stroke centers to optimize quality of care and improve outcomes (Fonarow et al., 2021). Currently, there are four recognized levels of stroke certification. Acute Stroke Ready Hospitals (ASRH) are able to recognize AIS, begin treatment and transfer to a higher level of care. Primary Stroke Centers (PSC) can care for a majority of AIS patients, and represent the majority of stroke certified hospitals in the US. Comprehensive Stroke Centers (CSC) treat the most complex neurovascular disease and participate in research to advance the science. Recently, Thrombectomy-capable Centers (TSC) were added; recognizing a level above PSC but below CSC, set apart by their ability to provide thrombectomy procedures. A set of guidelines to assist health systems in creating efficient processes for the hyperacute triage and treatment of these patients has also been established and is routinely updated (Powers et al., 2019). Also recognized was a need for established quality metrics trackable across all levels of stroke center certification to inform continuous quality improvement initiatives (Ormseth et al., 2017). The national registry, GWTG, fulfills this need and is updated regularly. Most recently, the AHA released a Scientific Statement updating the 2009 statement regarding the comprehensive nursing care of the patient with AIS (Ashcraft et al., 2021). The framework created by the AHA allows for centers to benchmark outcomes in comparison to other centers, creates a central registry (GWTG) and supports ongoing research leading to advances in care.

The one constant recognized in all the guidelines, statements and advisories is the importance of time. Interventions need to be delivered in as expeditious time as possible to prevent permanent neuronal loss and improve the efficacy of treatments. Stroke alerts mobilize the teams needed for treatment decisions and delivery, making them the first step in the effective treatment of AIS patients.

Use of HCGM applications in the stroke alert process

The use of HIPAA compliant group messaging (HCGM) applications are gaining increased acceptance in health care systems due to the increasing ubiquity of cell phones in the clinical care setting and seem an ideal format for the delivery of vital alerts like the Stroke Alert. Ventola (2014) discussed the value of applications linked to the EHR for rapid and secure access to patient information and images. According to the author, use of these type of applications was shown to improve accuracy and efficiency (Ventola, 2014). In one of the first studies to apply this technology to AIS patients, Shkirkova et al. (2017) implemented a comprehensive mobile platform for the hyper-acute triage and treatment of stroke. The authors demonstrated that this platform was easily adopted by staff and was associated with more rapid treatment times. In their review, Pourmand et al. (2018) found HCGM apps to be superior to traditional pager systems in two key areas: time efficiency and access to patient specific information. Increased time efficiency is an obvious objective in improving stroke processes; quick, remote access to patient information also supports better time utilization. As team members are moving toward the AIS patient, they can be reviewing available information, thereby arriving at the bedside better prepared to address the issues at hand. Most recently, groups like Matsumoto et al. (2019) and Seah et al. (2019) have used HCGM apps in their comprehensive platforms to guide and track ED AIS care. Both teams found improvement in communication among team members with the implementation of use of a HCGM app.

Computerized Physician Order Entry

The use of computer physician order entry (CPOE) is a standard at most hospitals in the United States. However, its use as a valuable component in streamlining hyper-acute stroke triage and treatment was a recent discovery. Heo et al. (2010) noted the value of CPOE in improving team communication and organization. They developed a CPOE-based program named Brain salvage through Emergent Stroke Therapy (BEST). BEST enables activation, communication, and notification to the stroke team as well as provision of guidelines and protocols via CPOE. This system was implemented across a 10 hospital system after a pilot study in a single hospital demonstrated reduction in DTN (Heo et al., 2010, p. 1979). Time intervals of DTCT and DTN were collected for a year after application of the CPOE program and compared to data from a year prior to implementation. The authors demonstrated a statistically significant improvement in DTCT as compared to retrospective data, with a reduction of an average of 7.7 ($p < 0.001$) (Heo et al., 2010, p. 1978). Additionally, they reduced DTN time from 71.7 ± 33.6 minutes to 56.6 ± 26.9 minutes ($p < 0.001$) which was also statistically significant (Heo et al., 2010, p. 1978).

Cho et al. (2014) implemented the BEST program in a process improvement project to reduce delays in treating AIS patients. They compared time metrics for AIS patients presenting to the ED for 1.5 years pre and post-implementation of the CPOE program. This process improvement again resulted in a statistically significant improvement in DTN time (63.5 to 45 minutes, $p = 0.001$), their key outcome indicator (Cho et al., 2014).

Yoo et al. (2016) also demonstrated reduction in time intervals to evaluation and reperfusion with the use of CPOE. The researchers created a code stroke process that utilized the BEST program but for patients who developed stroke symptoms while admitted for another indication, also known as an in-house stroke alert. Again, CPOE activated the stroke alert but mobilized the team to the patient's bedside, rather than to the ED. After the application of a CPOE model, this team demonstrated a decrease in symptom onset to CT time (91 minutes vs. 41 minutes; $p < 0.001$) as well as onset to treatment time (120 minutes vs. 65 minutes; $p < 0.001$), leading them to conclude that the use of CPOE was effective in speeding treatment for in-house stroke patients (p 656).

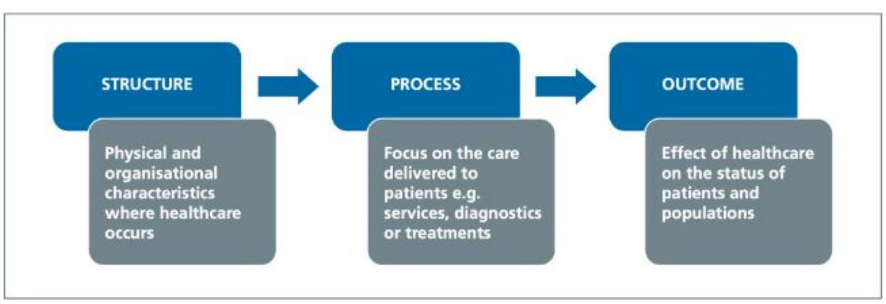
These studies (Cho et al., 2014; Heo et al., 2010; Yoo et al., 2016) demonstrate the feasibility of using CPOE to launch a time sensitive alert. The findings also validate that a CPOE alert did not lengthen and in fact in these cases, reduced time intervals like DTCT and DTN.

The Donabedian Model

The Donabedian Model (1988) for measuring quality care is the theoretical framework for assessing this quality improvement project. Donabedian (1988) defines three measures vital to consider when embarking on any quality improvement initiative: structure, process and outcome. The association of these three components is vital to understanding quality care. As Donabedian explains, "good structure increases the likelihood of good process, and good process increases the likelihood of a good outcome" (p 1745). These components are represented in Figure 1.

Figure 1

Donabedian Model



(Franklin, 2019)

Structure refers to the settings where care is provided. In Heo's (2010) and Cho's (2014) evaluation of the application of CPOE, the setting was the ED, while the setting for Yoo's (2016) work was the entire hospital. Process defines the way in which care is provided. The researchers who applied the BEST program (Cho et al., 2014; Heo et al., 2010; Yoo et al., 2016) changed the process of stroke alerts, adding the CPOE model. Likewise, Shirkova (2017) implemented a process change, adding the use of an HCGM app to the Stroke Alert. Outcome reflects the impact on the patient.

Donabedian's Model has been a useful framework for improving the quality of care for AIS patients. In 2006, the Donabedian Model was adopted by the German Stroke Registers Study Group to develop and implement quality indicators for AIS (Heuschmann et al., 2006). The authors addressed the lack of consensus in Germany regarding indicators of quality care of AIS patients, and identified 24 indicators based on Donabedian's Model, including availability of brain imaging (structure), screening of patients for swallowing disorders (process) and incidence of hospital-acquired pneumonia (outcome) (Heuschmann et al., 2006). More recently, the Donabedian Model has been used in an attempt to benchmark the quality of stroke centers providing thrombectomy. Amini et al. (2020), evaluated the structure and process of care for AIS patients in 17 Dutch centers who participated in the MR CLEAN (Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands) registry, a prospective, observational registry of all 17 centers that perform thrombectomy in the Netherlands (Amini et al., 2020). Structure indicators included center volumes and year of admission, as these reflect the experience of the center with thrombectomy (Amini et al., 2020). Process indicators included ED arrival time to time of thrombectomy start as well as if thrombectomy was performed under general anesthesia (Amini et al., 2020). The outcome measure was the Modified Rankin Scale (mRS) which is a measure of independence often used in stroke clinical trials (Banks & Marotta, 2007). The authors also collected data on the case mix index of these centers to assess impact of patient characteristics outside the center’s control like age, medical history, severity of stroke etc. on outcome. In their conclusion, while variations in outcomes were more likely related to differences in case mix, structure and process indicators were still vital to future benchmarking work. This is especially true for quality improvement work around time to treatment, where the improvement to outcome is clear (Amini et al., 2020).

Accurate assessment and expedited treatment of stroke patients is vital to protecting neurons and improving outcomes. Review of the literature supports utilizing CPOE to initiate the alert as shown in Heo (2010), Cho (2014) and Yoo (2016). The use of an HCGM application is also supported in Shirkova (2017) and Matsumoto (2019) and Seah (2019). Optimization of the EMR for communication and data collection to improve care for AIS patients is recommended by the latest AHA scientific statement from the AHA (Ashcraft et al., 2021). Evaluation and improvement of the hyper-acute portion of stroke work-up is dependent on data. Utilizing EMR linked resources like CPOE and HCGM allows for collection of that data in a reliable and efficient manner.

Chapter 3: Methodology

The purpose of this project is to implement a new Stroke Alerting process utilizing CPOE to launch the delivery of the alert via Haiku, a HCGM app. This will allow for access to data on all Stroke Alerts to inform continuous quality improvement for better AIS patient outcomes.

Protection of Human Subjects

Institutional Review Board (IRB) approval was granted by the IRBs at West Chester University and University of Pennsylvania. Following IRB approval from West Chester this project received approval from the Penn Medicine Director of Clinical Initiatives, Associate Clinical Informatics Officer, and was supported by the Penn Medicine Neuroscience Service Line and the Neurovascular Disease Team. Approval was also granted by HUP ED Governance who has authority over all projects completed in the ED (see Appendix A).

Theoretical Framework

The Donabedian Model (Donabedian, 1988) will inform the discussion of the methodology for this project. As demonstrated by the German Stroke Registers Study Group, the Donabedian Model is particularly useful when applied to the care of AIS patients, allowing them to identify appropriate metrics to reflect quality care (Heuschmann et al., 2006). Similarly, defining structure, process and outcomes guided the implementation of this quality improvement project.

Structure

An evaluation of the structure of the existing Stroke Alert was completed to assess the requirements needed to launch the new alert system. This was completed by meeting with the HUP ED clinicians and physically walking through each step of the current process. The ED clinicians were asked about any structural limitations to the current process. Special note was taken of equipment needed to launch the existing alert. The proposed Haiku Stroke Alert was then discussed identifying potential structural obstacles to adoption. As the Haiku alert is delivered via individual devices, a survey was completed to identify the devices carried by the Stroke Alert team members, termed the alerting pool. This survey also asked about use of Haiku to identify knowledge regarding the Haiku system (see Figure 2).

Figure 2

Alerting Pool Survey

Alert Recipient Name (Last, First)	Epic ID	Role	Use own device? (Y/N)	Currently uses Haiku? (Y/N)

Process

A thorough assessment of the existing stroke alert process was completed. The following process steps were assessed:

- Patient identification
  - How and where are ED patients identified as potentially suffering an AIS requiring a Stroke Alert?
  - How will this impact the Haiku Stroke Alert?

- Patient registration
  - Who and how are ED patients registered into PennChart?
  - Would timing of patient registration affect ability to launch a CPOE based alert?

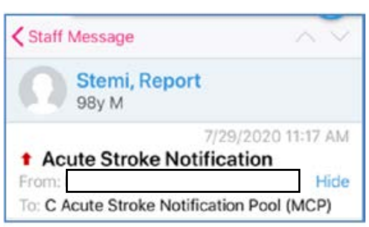
- Stroke Order set usage
  - How quickly is the Stroke Order set applied?
  - Would this be the best place to embed the Haiku Stroke Alert order?

- Initiation of the Stroke Alert
  - Who tells the Unit Secretary to initiate the existing Stroke Alert?
  - Would the same individual be responsible for initiating the Haiku Stroke Alert?

Findings of this assessment were brought back to the Penn Medicine Informatics team to inform the PennChart build of the Haiku alert. The Haiku Alert contains the patient name, location in ED, as well as a link to their record in PennChart (see Figure 3).

Figure 3

Haiku Stroke Alert



Stroke Alert Team members' knowledge of Haiku alerting was collected in the previously described Alerting Pool Survey (see Figure 2). Haiku naive Stroke Alert recipients were offered virtual instruction on how to download and receive Haiku Alerts. All Stroke Alert recipients were sent a Haiku tip sheet to ensure everyone had consistent information (see Appendix B). A test alert was sent 3 days prior to implementation to confirm all had downloaded the Haiku app appropriately and were able to receive the Stroke Alert.

Outcome

A follow-up meeting with the ED clinicians was completed 10 weeks after implementation of the Haiku alert, to elicit feed-back on the new process. The team was asked if there were any issues encountered in use of the Haiku Stroke alert. Additionally, feedback was elicited from the Stroke Alert Team recipients of the Haiku Stroke Alert, including Neurology Residents, and CT Techs. Stroke Alert Team members were asked about any issues receiving the Haiku alert, as well as opinions on the new process.

Using the data collection tool (see Appendix C), information was gathered for all Stroke Alerts for the 6 weeks following initiation of the Haiku alerting process. Data points included date, time of Haiku alert, time of Unit Secretary launched alert, ED door time, time of CT scan, if alteplase was given and the time given. Time differences between the Unit Secretary launched Stroke Alert and Haiku Alert, as well as DTCT times and DTN times were calculated. Data were collected by following the link to the patient record in the Haiku alert and reviewing the ED record.

The data collection tool (see Appendix C), was also used to gather information on the Stroke Alerts delivered the 6 weeks prior to initiation of the Haiku process. As the Unit Secretary launched Stroke Alerts were delivered via a de-identified text message, the text history on a linked device was manually reviewed. This allowed for the collection of date and time of alert, but none of the other data points were available using the previous system.

As it was not possible to obtain the DTCT and DTN times for the pre-implementation group due to the de-identified nature of the alerts, the GWTG database was utilized to compare these times pre and post-implementation. The GWTG database compiles data on metrics that track institutions compliance with AHA recommended guidelines for the care of the AIS patient.

The HUP Data Collection Nurse who maintains the hospital's GWTG registry was enlisted to provide a list of confirmed stroke patients who were admitted through the HUP ED for the 6 weeks pre and post-implementation of the new alerting process. The data was provided anonymously. These lists were compared to the pre and post-implementation data sets. For the pre-implementation group, matches were based on date and time of admission into the ED. With this identified sub-set, it was then possible to enter EHR to collect the additional data-points unavailable on the full data set. To allow for meaningful comparison, the set of post-implementation GWTG confirmed stroke patients was pulled from the larger post-implementation data-set by simply matching the date, and patient initials already collected.

This process resulted in data tables reflecting the total number of stroke alerts in the pre-implementation period. The post-implementation data table reflects total number of stroke alerts but also contains additional data points made available due to the new process. Obtaining GWTG curated data from each time period allowed for creation of data tables for purposes of comparison.

HIPAA compliance was maintained at all times. Data was reviewed by Dr. Laura Stein, Physician Lead of the Neurovascular Disease Team. Preliminary data was also reviewed with the HUP ED Governance group.

Chapter 4: Results

The goal of this project was to enhance the availability of data essential for the ongoing improvement of quality of care provided to patients suffering AIS at HUP. A Stroke Alert launched via CPOE and delivered via a HCGM app has the potential to allow for this enhanced data without impacting key metrics like DTCT and DTN times for these patients.

Theoretical Framework

Amini et al. (2020) utilized the Donabedian Model to evaluate the care processes for patients in the MR CLEAN registry. This registry was developed in the course of completing the MR CLEAN trial which tested the efficacy of mechanical thrombectomy for AIS caused by a large vessel occlusion (Amini et al., 2020). Applying the lens of the Donabedian Model (1988) allowed the authors to draw important conclusions regarding the importance of particular facets of structure and process most likely to lead to improved outcomes for AIS patients. This lens will be applied to the results of this quality improvement project.

Structure

The evaluation of the structure of the Stroke Alert process identified obstacles present in the existing system which could impact the implementation of the new system. When walking through the HUP ED, multiple desktop computers and work-stations on wheels were noted. None were designated for individual users, which was identified as a potential obstacle to the prompt ordering of the Stroke Alert, as the admitting physician who needs to place the orders may not have access to a computer when needed. Based on this evaluation, a dedicated computer was identified for clinician order entry to launch the alert.

The Haiku Stroke Alert is delivered to individual devices, so the Alerting Pool Survey was completed to identify these devices. The survey revealed some Stroke Alert Team members, specifically the CT technicians, do not carry devices that could receive Haiku alerts, instead using pagers. Penn Medicine Informatics created a pathway for these devices to receive a de-identified alert, while the rest of the pool received the Haiku alert.

Process

Assessment of the Stroke Alert process from patient identification to initiation of alert revealed important challenges that needed to be addressed for the successful implementation of the Haiku alerting process.

Initiation of the Stroke Alert

In the previous Stroke Alert process, the Unit Secretary was verbally instructed to activate a Stroke Alert. The alert was activated by clicking a link on the Penn Medicine Intranet which triggered a de-identified alert message to preprogrammed phone or pager numbers. The new Haiku Stroke Alert will be launched via an order embedded in the existing Stroke Order Set which does not change current ED clinician practice.

Identification and registration

Many patients presenting to the HUP ED with signs and symptoms of AIS are identified in the ED triage area. Others are identified by Emergency Medical Services (EMS) in the field and are called into the ED by paramedics while en route. This notification, known as a Haste Call, is made to alert the ED team to prepare for a potential AIS patient. In the existing Stroke Alert process, the Stroke Alert would be launched on this call, to alert the team of an incoming AIS patient. The new Haiku Alert is launched via CPOE and since orders cannot be placed in PennChart until the patient arrives and is admitted to the ED, it is impossible to launch a Haiku alert on the Haste Call while the patient is still en route. To avoid jeopardizing the ability of the response team to receive this early notification, the existing Unit Secretary launched Stroke Alert process will remain for these Haste calls, with the expectation that the Haiku Stroke Alert order will be applied on patient arrival. The ED team has a robust system for the immediate registration and admission of ED patients therefore this process was not expected to present an obstacle to the prompt ordering of the Haiku alert in patients arriving by EMS after a Haste Call.

Stroke Order Set

The ED team reported consistent use of the Stroke Order Set for all suspected AIS patients. This order set includes orders for required imaging and lab work for a suspected AIS patient. Since time sensitive orders are included in the Stroke Order Set, the ED team places this order set expeditiously for these patients. The Haiku Stroke Alert order was imbedded in this order set.

Outcome

During the post-implementation follow-up with the ED team, the prevailing opinion was that activation of the Haiku Stroke Alert was indistinguishable to the previous process. With the Haiku alert order embedded in the existing Stroke Order Set, there was no obvious change in process of launching a Stroke Alert for the ED. In review of data with the ED team, occasional instances of greater than 5 minutes difference in Haiku Alert delivery as compared to existing alert were noted. The ED team judged these occurrences to likely be caused by an initiation of the Unit Secretary initiated Stroke Alert on the Haste Call from EMS. Data now available within Penn Chart as a result of the Haiku Stroke Alert was reviewed with the Medical Director of the ED. This finding led to further discussion of potential application and value of this data to clinical effectiveness and quality improvement work.

Reaction to the Haiku Stroke Alert process was positive from the team members receiving the alert. Neurology Residents who receive and respond to the Stroke Alerts in the ED noted consistency of alert information, including proper spelling of the patient name and the medical record number. Another benefit noted by this group was the access to the patient record via the Haiku app while en route to the ED in response to the Stroke Alert. There have been frequent requests to move alerts for other processes to this model from the resident team.

Pre-implementation data

A total of 70 ED Stroke Alerts were documented in the 6-week pre-implementation period. Average DTCT time was 17 minutes; IV Alteplase was given twice. Average DTN time was 45 minutes. A sample of the data collected is represented in Table 1. The full data-set table can be found in Appendix D. Blank spaces represent the data unavailable prior to implementation of the Haiku Stroke Alert process.

Table 1

Pre-Implementation Data

Patient #	Date of Alert	Time of Unit Secretary Initiated Alert (USIA)	ED Door Time	CT Time	tPA (Y/N)	Needle Time	Door to CT Time (minutes)	Door to Needle Time (minutes)
1	11/23/2020	11:18						
2	11/23/2020	17:04						
3	11/23/2020	20:57						
4	11/24/2020	15:12						
5	11/25/2020	8:40						

Sixteen of the 70 alerts were validated as AIS and included in the GWTG registry. These are reflected in Table 2. As they were included in GWTG, full data was available.

Table 2

Pre-Implementation Data - GWTG Validated

Patient #	Date of Alert	Time of Unit Secretary Initiated Alert (USIA)	ED Door Time	CT Time	tPA (Y/N)	Needle Time	Door to CT Time (minutes)	Door to Needle Time (minutes)
1 (MO)	11/23/2020	11:18	11:13	11:33	Y	11:52	20	39
8(KS)	11/28/2020	2:37	2:35	2:44	N	n/a	9	n/a
10 (JH)	11/29/2020	10:41	10:35	10:45	N	n/a	10	n/a
11 (LJ)	11/29/2020	11:19	11:16	11:29	N	n/a	13	n/a
23 (CM)	12/7/2020	9:17	9:09	9:21	N	n/a	12	n/a
24 (MP)	12/7/2020	12:02	11:52	12:09	Y	12:43	17	51
37 (DM)	12/13/2020	0:24	0:14	0:32	N	n/a	18	n/a
38 (AC)	12/13/2020	11:33	11:37	11:45	N	n/a	8	n/a
43 (FJ)	12/16/2020	23:49	0:03	0:17	N	n/a	15	n/a
48 (JW)	12/18/2020	11:58	11:29	12:29	N	n/a	60	n/a
56 (VG)	12/23/2020	18:42	18:55	19:05	N	n/a	10	n/a
59 (MD)	12/26/2020	2:08	1:59	2:24	N	n/a	25	n/a
60 (CW)	12/26/2020	13:51	13:58	14:11	N	n/a	13	n/a
65 (CM)	12/31/2020	9:44	9:36	9:48	N	n/a	12	n/a
67 (WG)	1/1/2021	10:04	10:11	10:20	N	n/a	9	n/a
70(DJ)	1/2/2021	13:07	12:58	13:15	N	n/a	17	n/a

Post-implementation data

A total of 80 ED Stroke Alerts were recorded in the 6-week post-implementation period. Average DTCT time was 19 minutes. IV alteplase was given in 3 cases. Average DTN time was 43 minutes. A sample of this data-set is represented in Table 3. The full data-set can be found in Appendix E.

Table 3

Post-Implementation Data

Patient #	Date of Alert	Time of Haiku Alert	Time of Unit Secretary Initiated Alert (USIA)	Minutes Difference (USIA - Haiku)	Time Difference (USIA-Haiku)	ED Door Time	CT Time	tPA (Y/N)	Needle Time	Door to CT Time (minutes)	Door to Needle Time (minutes)
1 (AD)	1/4/2021	22:36	22:44	8	0:08	22:29	22:51	N	n/a	22	n/a
2 (AR)	1/4/2021	23:01	22:51	-10	-0:10	22:56	23:13	Y	23:47	17	51
3 (VM)	1/5/2021	15:03	15:11	8	0:08	14:43	15:08	N	n/a	25	n/a
4 (AE)	1/5/2021	17:03	17:06	3	0:03	15:38	16:11	N	n/a	33	n/a
5 (DS)	1/6/2021	11:45	11:44	-1	-0:01	11:31	11:54	N	n/a	43	n/a

Fourteen of the 80 alerts were validated as AIS and included in the GWTG registry. These are reflected in Table 4.

Table 4

Post-Implementation Data - GWTG Validated

Patient #	Date of Alert	Time of Haiku Alert	Time of Unit Secretary Initiated Alert (USIA)	Minutes Difference (USIA - Haiku)	Time Difference (USIA-Haiku)	ED Door Time	CT Time	tPA (Y/N)	Needle Time	Door to CT Time (minutes)	Door to Needle Time (minutes)
2 (AR)	1/4/2021	23:01	22:51	-10	-0:10	22:56	23:13	Y	23:47	17	51
3 (VM)	1/5/2021	15:03	15:11	8	0:08	14:43	15:08	N	n/a	25	n/a
10 (NI)	1/9/2021	9:55	9:55	0	0:00	9:46	10:03	N	n/a	17	n/a
11 (AA)	1/9/2021	21:21	21:21	0	0:00	21:08	21:28	N	n/a	20	n/a
24 (GG)	1/15/2021	8:36	*alert system offline			8:35	8:44	Y	9:23	9	48
25 (YB)	1/15/2021	13:37	*alert system offline			13:34	13:50	Y	14:07	16	33
27 (AM)	1/17/2021	13:33	13:36	3	0:03	13:26	13:37	N	n/a	11	n/a
31(MG)	1/18/2021	12:48	12:50	2	0:02	12:36	13:07	N	n/a	31	n/a
33 (MK)	1/19/2021	11:55	none			11:50	12:12	N	n/a	22	n/a
47 (IS)	1/24/2021	21:10	21:02	-8	-0:08	21:05	21:18	N	n/a	13	n/a
52 (EG)	1/27/2021	8:00	7:49	-11	-0:11	7:49	8:10	Y	8:28	21	39
55 (DH)	1/27/2021	11:00	10:58	-2	-0:02	10:45	11:16	N	n/a	31	n/a
66 (DG)	2/3/2021	14:33	14:33	0	0:00	14:28	14:47	N	n/a	19	n/a
76 (CB)	2/12/2021	5:43	5:44	1	0:01	5:39	5:49	N	n/a	10	n/a

Comparison

Comparison of DTCT and DTN times for the pre and post-implementation GWTG validated groups revealed the following (see Table 5):

Table 5

DTCT and DTN Comparison

	Pre-implementation	Post-Implementation
DTCT	17 minutes	19 minutes
DTN	45 minutes	43 minutes

DTCT times increased by 2 minutes in the post-implementation period, while the DTN time was decreased by 2 minutes.

Because the existing alerting process was maintained, it was possible to compare the time differences between the delivery of that alert and the Haiku alert in the Post-Implementation period to evaluate the effect of the Haiku alert on DTCT time. The Unit Secretary launched system had technical difficulties during the post-implementation monitoring period, making that alert unavailable for 14 of those alerts. Another alert did not have a HCT, leaving a total of 65 cases for comparison. There were 32 alerts where the Haiku alert was delivered earlier or at the same time as the Unit Secretary launched alert. The range for these was 0 to 8 minutes, with a mean of 2 minutes and a median of 1 minute. Thirty-three Haiku alerts were delivered after the Unit Secretary initiated alert with a range of 1 – 16 minutes, a mean of 5 minutes and a median of 3 minutes. The comparison of the DTCT times for these two groups was similar with the mean and median slightly less in the delayed Haiku group, indicating that the use of the Haiku alert is less likely to be the cause of the slight increase in the DTCT time in the post-implementation group (see Table 6).

Table 6

DTCT Comparison Early vs. Late Haiku Alert

	Early Haiku Alert	Late Haiku Alert
Range	10 – 191 minutes	7 – 129 minutes
Mean	32 minutes	27 minutes
Median	20.5 minutes	20 minutes

As a result of the institution of the Haiku stroke alert process, important metrics are available for all Stroke Alerts called by the ED. Previously, total volume of Stroke Alerts issued was the only easily knowable metric, and even that required a manual count. Metrics including DTCT and DTN were available for a small subset of all stroke alerts: those with a confirmed diagnosis of AIS and entered in the GWTG database. The new Haiku Stroke Alert process allows for collecting of DTCT for all Stroke Alerts issued as it is initiated by an order in PennChart. Based on comparisons of the GWTG curated data for the pre and post-implementation periods, there was no significant difference in DTCT or DTG with the Haiku Stroke Alert process. The Haiku Stroke Alert process was reported to be easy to use by the ED team. The Neurology residents who receive the Haiku Alert reported satisfaction with the Haiku Stroke Alert due to its ability to consistently deliver accurate patient information as well as access to the patient EHR via the app.

Chapter 5: Discussion

AIS patients require hyper-acute evaluation to allow for treatment decision-making. Every second of delay from presentation to delivery of treatment represents neurons lost, leading to the mantra, “time is brain” (Saver, 2005, p. 263). This quality improvement project was implemented to improve the access to data on the earliest part of the hyper-acute evaluation, the Stroke Alert, which brings vital team members to the patient’s bedside.

Theoretical Framework

The Donabedian Model (1988) of quality improvement posits that one must evaluate structure, process and outcome. Data on each of these pillars is needed to make the assessments to make meaningful change. Better access to data in the setting of the care of the AIS patient can lead to identification of opportunities to decrease time to treatment. The ultimate goal of this quality improvement work is to use data to save brain, therefore, “data is time” in much the way “time is brain”. This section provides a description of the limitations and implications of this quality improvement project.

Structure

This quality improvement project allowed for the delivery of the Stroke Alert to devices which carried the HCGM app Haiku. As noted earlier, CT technicians utilize pagers rather than a Haiku enabled device which led to the need for a work-around process to be built with-in Penn Chart to allow for the alert to go to the pager devices. It is worth exploring the value that might be added by equipping this team with devices that can receive the Haiku alert. Early access to information contained in PennChart would be helpful to have in advance of the patients' arrival at the CT scanner; for example, weight and existence of a dye-allergy. Knowledge of this information could potentially prevent delays in the acquisition of images.

Process

The new Haiku Stroke Alert process begins with placing the order in the patient record to launch the alert. Frequently the ED staff is alerted to patients arriving via EMS while still en route by a Haste Call placed by the paramedics. Currently, orders cannot be placed until a patient is admitted to the ED, making it impossible to order a Haiku alert on the Haste Call. The plan put in place during this project to maintain the Unit Secretary initiated alerts for these cases allowed for continued early alerting of the teams, but is not ideal. Redundant systems lend themselves to confusion. To retire the old alerting process, it would be necessary to develop a pathway within PennChart to allow for early registration of patients, permitting the ED team to place the order launching the Haiku alert. While the ED has a process to expeditiously register and admit patients, it may be beneficial to evaluate the institution of an early registration process which might itself offer a time savings for these patients as compared to the existing model.

Outcome

This quality improvement project demonstrated the feasibility of delivering highly timed sensitive alerts to a medical team via the HCGM app Haiku. One of the most frequent queries heard from the resident team who received the Haiku alert was when other alerts they currently receive could be migrated to the Haiku process. One example is the alert sent upon the recognition of stroke symptoms in a currently hospitalized patient. These “In-House Stroke Alerts” are currently delivered in a similar manner to the ED Unit Secretary initiated alerts. The In-House Stroke Alert is initiated by a call to the hospital operator who launches an alert identifying only the patient room to pre-populated phone numbers. Again, this alert does not originate with an order, so exists outside the patient record. For these patients, the ability to link to the patient record to review while moving to the patient is especially meaningful as the team could arrive at the bedside knowing the reason for the patient's admission and subsequent hospital course. This is vital information to make a treatment decision for AIS. Another alert that could benefit from migration to the Haiku model is the alert delivered once an AIS patient has been accepted in transfer from an outside hospital. This most frequently occurs when a patient presents to a Primary Stroke Center but requires treatment only available at a Comprehensive Stroke Center. An alert is sent to a response team who meet the patient at the CT scanner where additional imaging is reacquired to make a treatment decision. A Haiku alert could again, link to the patient record, but this process would be dependent on a PennChart solution for early registration/admission as described for ED Haste Call patients.

The most important outcome of this quality improvement project is the accessibility of data for all Stroke Alerts. It is now possible to create an automated report in PennChart of all Stroke Alerts. This report can be customized to include the metrics of DTCT and DTN noted in this project, but could also include other important data points like time to Neurology arrival and outcome.

The patient's presenting symptoms, which lead the team to initiate a Stroke Alert, and the ultimate discharge diagnosis are data points that might inform future clinical effectiveness and quality improvement initiatives. As demonstrated by the results of this project, only a small subset of all stroke alerts go on to AIS diagnosis and treatment. Previously, there was no way to look at data on the non-AIS diagnosed Stroke Alert population. With this new alerting process, there is access to robust data on all Stroke Alerted patients. This allows for consideration of stratified Stroke Alerting, as one example of a potential improvement. Data allows for a review of all presenting symptoms for stroke alerted patients, comparing those who go on to an AIS diagnosis and treatment to those that do not. It may be that those who present with aphasia and hemiparesis, for example, may be much more likely to go on to treatment than those who present with discrete numbness. These data could lead to a stratified alert where those with hemiparesis and aphasia receive all imaging required for treatment decision making upfront, while those without those symptoms only receive a standard head CT until a neurologic exam demonstrated the need for further imaging. Stratification of the stroke alert has the potential to prevent unnecessary imaging for patients. A stratified alerting model may also allow for better utilization of resources. A standard head CT can be completed in about 10 minutes. The full imaging required for treatment decision making, including CT angiogram and CT perfusion studies, can add about 15 minutes to that time. In a busy ED, the CT scanner is in high demand. While a potential stroke patient is being imaged, other ED patients are waiting. Reducing the number of patients requiring all three images upfront could lead to improved through-put in the ED.

Consideration of discharge data may also offer guidance on the appropriate use of Stroke Alerting. Concern of over-use of the Stroke Alert has been a consistent complaint of responding teams. Until now, there has been no way to access data, making it impossible to quantify positive (appropriate) vs. negative (inappropriate) alerts. Based on the small data set collected in the 12 weeks of this project, only 21% of alerts resulted in a diagnosis of AIS, based on the GWTG data sets. These data sets did not include transient ischemic events or migraines, other diagnoses that would represent an appropriate use of the Stroke Alert; so that percentage is likely higher, but it would not be expected that these diagnoses would be present in a large number. A certain amount of "over-calling" of Stroke Alerts is to be expected, if not outright encouraged, to prevent missing a treatable AIS patient. But, it's unclear what constitutes the "right" ratio. Exploring this question could lead to improved assessment, alerting and educational initiatives.

Conclusion

This quality improvement project was instituted to address the lack of data available to assess the Stroke Alert process. Utilizing the Donabedian Model (1988) as a guide, the existing Stroke Alert system structure and process were assessed as well as the relation to outcome. Based on this assessment, a new CPOE based alert process utilizing the HCGM app Haiku was instituted. This process proved feasible, receiving positive feed-back from ED team who requests the alert and the Neurology resident team who receives the alert. The Haiku alert did not appreciably add time to the DTCT or DTN times. The most important outcome of this process is the access to comprehensive data that can now be used to explore other avenues to improve the hyperacute phase of AIS triage and treatment. The availability of robust Stroke Alert data was the missing foundational element allowing for clinical effectiveness and quality improvement work.

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Appendix A
IRB West Chester University IRB Approval

WCU
WEST CHESTER UNIVERSITY

Office of Research and Sponsored Programs | West Chester University | Ehinger Annex West Chester, PA 19383 | 610-436-3557 | www.wcupa.edu

Protocol ID # 20200105D
This Protocol ID number must be used in all communications about this project with the IRB.

TO: Michele Sellers and Cheryl Monturo

FROM: Nicole M. Cattano, Ph.D.
Co-Chair, WCU Institutional Review Board (IRB)

DATE: 1/4/2021

Project Title: Improvement of Stroke Alerting Process Utilizing an Epic Based HIPPA Compliant Group Messaging Application

Notification of Initial Study Exemption Determination

☒**Exempt From Further Review**

This Initial Study submission meets the criteria for exemption per the regulations found at 45 CFR
46.104 (4). As such, additional IRB review is not required.

The determination that your research is exempt does not expire, therefore, annual review is not required and no expiration date will be listed on your approval letter. If changes to the research are proposed that would alter the IRB's original exemption determination, they should be submitted to the WCU IRB for approval, using the IRB application form (check off I.G. Revision).

Your research study will be archived 3 years after initial determination. If your Exempt study is archived, you can continue conducting research activities as the IRB has made the determination that your project met one of required exempt categories. The only caveat is that no changes can be made to the application. If a change is needed, you will need to submit a NEW Exempt application. Please see www.wcupa.edu/research/irb.aspx for more information.

However, it is very important that you *close-out your project when completed or if you leave the university*. Faculty mentors are responsible for oversight of student projects and should ensure exempt studies are completed and closed-out before the student leaves the university.

The Principal Investigator and/or faculty mentor is responsible for ensuring compliance with any applicable local government or institutional laws, legislation, regulations, and/or policies, whether conducting research internationally or nationally. Please contact the WCU Office of Sponsored Research and Programs at irb@wcupa.edu with any questions.

Sincerely,

Co-Chair of WCU IRB

WCU Institutional Review Board (IRB)
IORG#: IORG0004242
IRB#: IRB00005030
FWA#: FWA00014155

West Chester University is a member of the State System of Higher Education

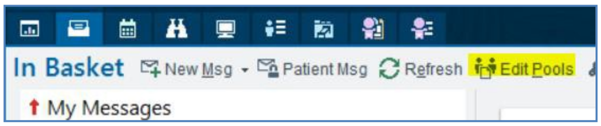
Appendix B

Haiku Alert Tip Sheet

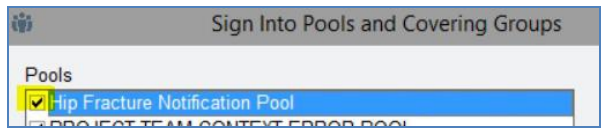
PennChart Haiku Push Notifications

How to set up Haiku on your device

1) To receive the In Basket messages, you need to Sign In to the your Notification Pool. This can be done from PennChart Hyperspace.



→



If you do not see that Pool, then please contact your pool manager to be added.

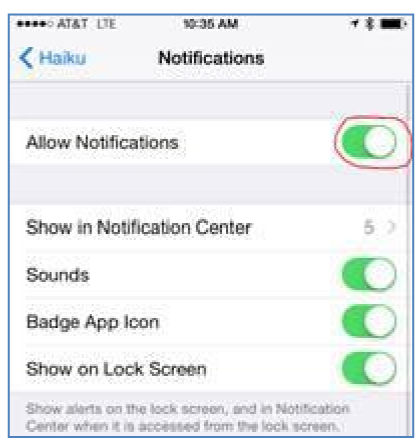
2) If you do not already use Haiku, then download it from the Apple App Store by searching "Epic Haiku"

3) Setup Haiku for PennChart.
The easiest way to configure the device it to use the QR code below. It requires iOS 11 or later on your phone. You can scan the QR code by opening the camera app on your phone and pointing the camera to the code below. You will get a little pop up within the app that says "Open in Haiku", click on that button and it should take you back to the log in screen.

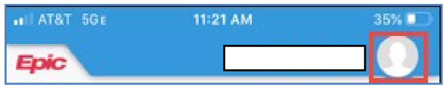
At the top of the login screen, you should see "PennChart Production". If you don't, please click on the custom configuration text and choose "PennChart Production". You should now be able to use your username and password to log in.

4) Verify that Haiku has Push Notifications turned on from the Settings on the iPhone. This works like other apps.

Settings App →Haiku →Notifications →

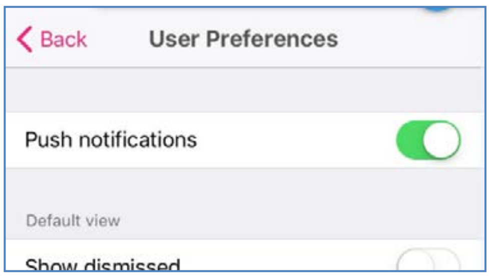


5) Log into Haiku and turn on the Opt In push notification types for PennChart specifically:

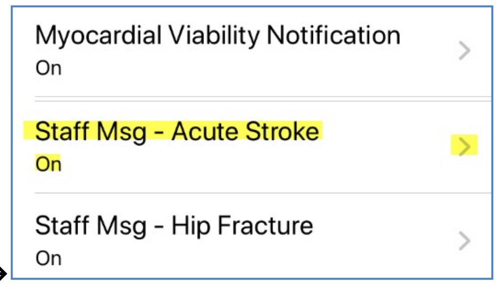


From Haiku →Go to Profile →→Notification Settings

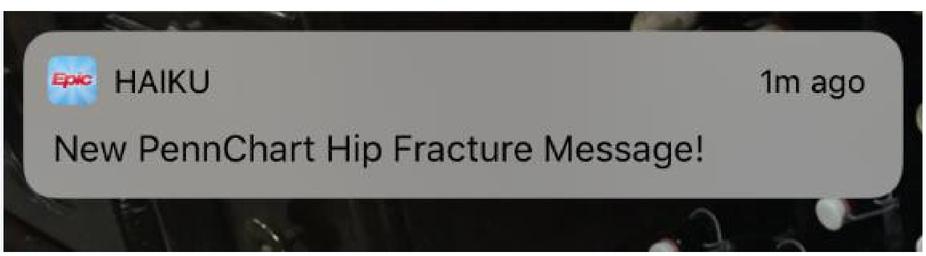
Make sure Pushes are turned on for PennChart and then Opt In (enable) the *your* notification type under show me banner/sound alert for:



→→
→→



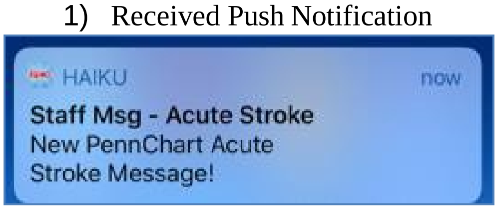
6) You will then get both the In Basket message and the push notification for *your* notification. The push notifications would show up on your iPhone as well as your Apple Watch if you had one:



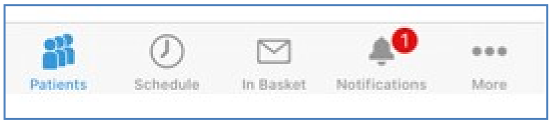
7) If you do not find the pushes helpful, then you can turn the specific message types back off again.

How to receive notification and view patient information?

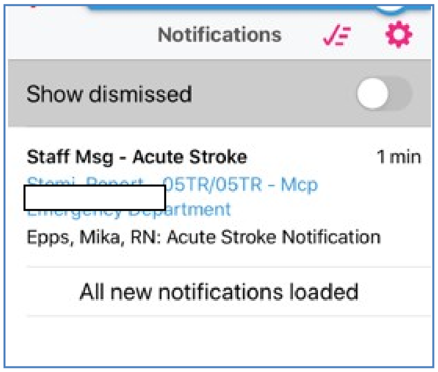
1) Received Push Notification

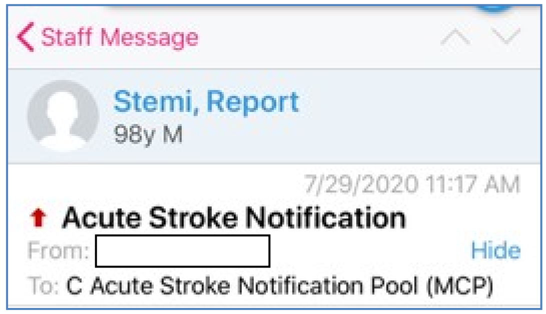


2) Open Haiku and select Notification icon

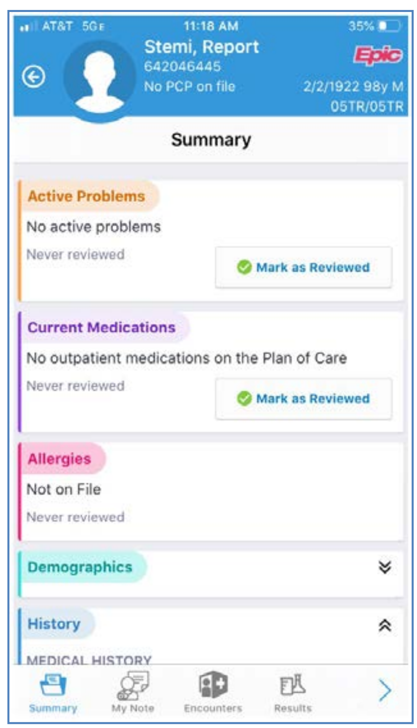


3) You can see patient demographic information (patient location)

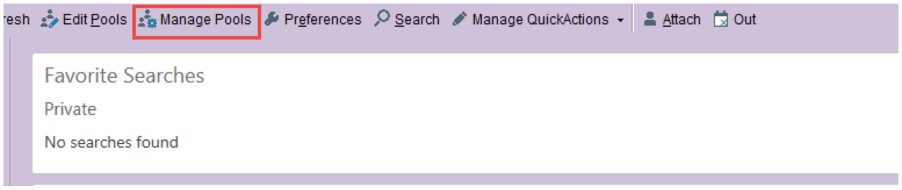




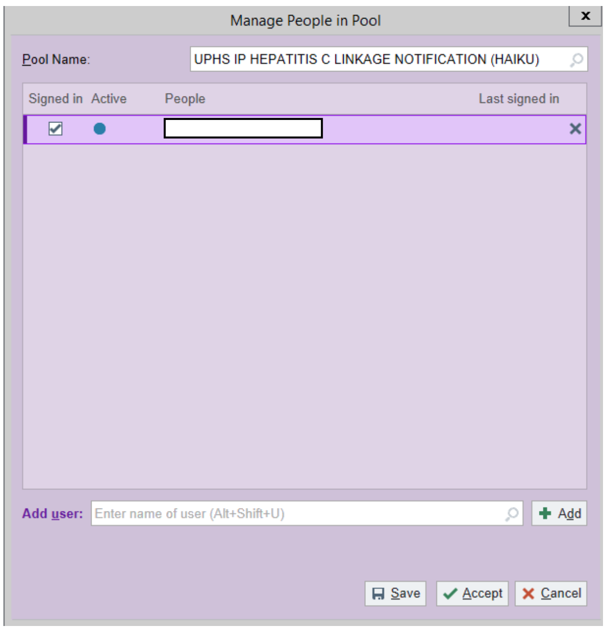
4) You can access to patient summary from selecting patient name



To Manage Pool (Pool Manager Only)



1) Open up Manage Pools
2) Type your pool name
3) Find user and add their name. Click on Signed in automatically sign on this pool for the user.



Appendix C

Data Collection Tool

Patient #	Date of Alert	Time of Haiku Alert	Time of Unit Secretary Initiated Alert (USIA)	Minutes Difference (USIA - Haiku)	Time Difference (USIA- Haiku)	ED Door Time	CT Time	tPA (Y/N)	Needle Time	Door to CT Time (minutes)	Door to Needle Time (minutes)

Appendix D

Pre-Implementation Data

Patient #	Date of Alert	Time of Unit Secretary Initiated Alert (USIA)	ED Door Time	CT Time	tPA (Y/N)	Needle Time	Door to CT Time (minutes)	Door to Needle Time (minutes)
1	11/23/2020	11:18						
2	11/23/2020	17:04						
3	11/23/2020	20:57						
4	11/24/2020	15:12						
5	11/25/2020	8:40						
6	11/26/2020	23:54						
7	11/27/2020	15:48						
8	11/28/2020	2:37						
9	11/28/2020	11:37						
10	11/29/2020	10:41						
11	11/29/2020	11:19						
12	11/29/2020	15:51						
13	11/30/2020	11:06						
14	12/1/2020	13:13						
15	12/1/2020	14:45						
16	12/1/2020	17:33						
17	12/2/2020	16:06						
18	12/2/2020	19:08						
19	12/3/2020	9:19						
20	12/3/2020	16:11						
21	12/4/2020	22:43						
22	12/6/2020	2:30						
23	12/7/2020	9:17						
24	12/7/2020	12:02						
25	12/7/2020	13:11						
26	12/7/2020	15:31						
27	12/7/2020	21:23						
28	12/8/2020	1:31						
29	12/8/2020	3:18						
30	12/8/2020	8:27						
31	12/8/2020	9:50						
32	12/10/2020	15:47						
33	12/11/2020	4:50						
34	12/11/2020	13:38						
35	12/12/2020	11:53						
36	12/12/2020	20:06						
37	12/13/2020	0:24						
38	12/13/2020	11:33						
39	12/14/2020	13:48						
40	12/15/2020	20:01						
41	12/15/2020	21:27						
42	12/16/2020	15:27						
43	12/16/2020	23:49						
44	12/17/2020	10:56						
45	12/18/2020	7:05						
46	12/18/2020	9:10						
47	12/18/2020	11:15						
48	12/18/2020	11:58						
49	12/18/2020	18:06						
50	12/19/2020	14:08						
51	12/20/2020	0:00						
52	12/21/2020	4:25						
53	12/21/2020	6:21						
54	12/22/2020	16:53						
55	12/22/2020	17:18						
56	12/23/2020	18:42						
57	12/24/2020	18:33						
58	12/25/2020	12:35						
59	12/26/2020	2:08						
60	12/26/2020	13:51						
61	12/26/2020	17:15						
62	12/26/2020	18:08						
63	12/27/2020	20:40						
64	12/29/2020	12:09						
65	12/31/2020	9:44						
66	1/1/2021	9:54						
67	1/1/2021	10:04						
68	1/1/2021	18:01						
69	1/2/2021	11:50						
70	1/2/2021	13:07						

Appendix E

Post-Implementation Data

Patient #	Date of Alert	Time of Haiku Alert	Time of Unit Secretary Initiated Alert (USIA)	Time Difference (USIA-Haiku)	ED Door Time	CT Time	tPA (Y/N)	Needle Time	Door to CT Time (minutes)	Door to Needle Time
1 (AD)	1/4/2021	22:36	22:44	0:08	22:29	22:51	N	n/a	22	n/a
2 (AR)	1/4/2021	23:01	22:51	-0:10	22:56	23:13	Y	23:47	17	51
3 (VM)	1/5/2021	15:03	15:11	0:08	14:43	15:08	N	n/a	25	n/a
4 (AE)	1/5/2021	17:03	17:06	0:03	15:38	16:11	N	n/a	33	n/a
5 (DS)	1/6/2021	11:45	11:44	-0:01	11:31	11:54	N	n/a	43	n/a
6 (WH)	1/7/2021	15:19	15:17	-0:02	14:22	15:32	N	n/a	70	n/a
7 (RE)	1/7/2021	19:14	19:16	0:02	19:07	22:18	N	n/a	191	n/a
8 (EM)	1/7/2021	20:57	20:47	-0:10	20:55	21:13	N	n/a	18	n/a
9 (KW)	1/8/2021	2:29	2:28	-0:01	2:02	2:39	N	n/a	37	n/a
10 (NI)	1/9/2021	9:55	9:55	0:00	9:46	10:03	N	n/a	17	n/a
11 (AA)	1/9/2021	21:21	21:21	0:00	21:08	21:28	N	n/a	20	n/a
12 (OH)	1/10/2021	12:41	12:43	0:02	12:14	12:52	N	n/a	38	n/a
13 (RA)	1/10/2021	13:53	none		13:37	14:07	Y	15:23	30	106
14 (SL)	1/11/2021	12:42	12:41	-0:01	12:33	12:58	N	n/a	25	n/a
15 (CS)	1/11/2021	14:00	13:59	-0:01	13:40	14:11	N	n/a	31	n/a
16 (RW)	1/12/2021	11:13	11:14	0:01	10:09	11:22	N	n/a	73	n/a
17 (SP)	1/12/2021	13:50	13:43	-0:07	13:36	13:54	N	n/a	18	n/a
18 (JM)	1/13/2021	10:54	*alert system offline		10:22	none	N	n/a		n/a
19 (JH)	1/13/2021	17:24	*alert system offline		17:14	17:33	N	n/a	19	n/a
20 (SW)	1/13/2021	17:51	*alert system offline		17:42	18:06	N	n/a	24	n/a
21 (AC)	1/14/2021	10:47	*alert system offline		10:38	10:57	N	n/a	19	n/a
22 (DG)	1/14/2021	11:56	*alert system offline		11:40	none	N	n/a		n/a
23 (BU)	1/14/2021	13:09	*alert system offline		12:56	13:17	N	n/a	21	n/a
24 (GG)	1/15/2021	8:36	*alert system offline		8:35	8:44	Y	9:23	9	48
25 (YB)	1/15/2021	13:37	*alert system offline		13:34	13:50	Y	14:07	16	33
26 (ON)	1/16/2021	11:14	*alert system offline		10:58	11:19	N	n/a	21	n/a
27 (AM)	1/17/2021	13:33	13:36	0:03	13:26	13:37	N	n/a	11	n/a
28 (AA)	1/18/2021	3:42	3:42	0:00	3:38	3:49	N	n/a	11	n/a
29 (DR)	1/18/2021	11:00	11:02	0:02	10:58	11:16	N	n/a	18	n/a
30 (DC)	1/18/2021	11:36	11:35	-0:01	11:27	11:47	N	n/a	20	n/a
31(MG)	1/18/2021	12:48	12:50	0:02	12:36	13:07	N	n/a	31	n/a
32 (AM)	1/18/2021	18:46	18:45	-0:01	18:36	18:59	N	n/a	23	n/a
33 (MK)	1/19/2021	11:55	none		11:50	12:12	N	n/a	22	n/a
34 (QS)	1/19/2021	16:39	16:41	0:02	16:19	16:51	N	n/a	32	n/a
35 (RG)	1/19/2021	19:21	none		18:57	19:11	N	n/a	14	n/a
36 (RB)	1/20/2021	13:13	none		12:59	none	N	n/a		n/a
37 (MLB)	1/20/2021	18:50	18:50	0:00	18:45	18:57	N	n/a	12	n/a
38 (BF)	1/21/2021	5:06	5:07	0:01	5:01	5:13	N	n/a	12	n/a
39 (AM)	1/21/2021	16:48	16:47	-0:01	16:46	16:56	N	n/a	10	n/a
40 (SM)	1/21/2021	21:51	21:55	0:04	21:37	21:58	N	n/a	21	n/a
41 (MT)	1/22/2021	8:25	8:13	-0:12	8:23	8:30	N	n/a	7	n/a
42 (CH)	1/22/2021	11:01	10:52	-0:09	10:59	11:10	N	n/a	11	n/a
43 (FJ)	1/24/2021	8:29	8:19	-0:10	8:22	8:34	N	n/a	12	n/a
44 (DB)	1/24/2021	9:58	9:59	0:01	9:45	10:08	N	n/a	23	n/a
45 (GP)	1/24/2021	13:24	13:24	0:00	13:04	13:37	N	n/a	33	n/a
46 (HHY)	1/24/2021	17:03	17:04	0:01	16:35	16:47	N	n/a	12	n/a
47 (IS)	1/24/2021	21:10	21:02	-0:08	21:05	21:18	N	n/a	13	n/a
48 (ZZ)	1/25/2021	19:15	19:23	0:08	18:43	19:21	N	n/a	38	n/a
49 (WTG)	1/26/2021	11:19	11:19	0:00	11:06	11:26	N	n/a	20	n/a
50 (SGJ)	1/26/2021	18:13	18:12	-0:01	18:00	22:37	N	n/a	27	n/a
51 (CS)	1/26/2021	18:37	18:33	-0:04	16:35	18:44	N	n/a	129	n/a
52 (EG)	1/27/2021	8:00	7:49	-0:11	7:49	8:10	Y	8:28	21	39
53 (RC)	1/27/2021	9:37	9:37	0:00	9:34	9:44	N	n/a	10	n/a
54 (NI)	1/27/2021	10:25	10:21	-0:04	10:10	10:39	N	n/a	20	n/a
55 (DH)	1/27/2021	11:00	10:58	-0:02	10:45	11:16	N	n/a	31	n/a
56 (PM)	1/28/2021	13:00	13:03	0:03	12:49	13:14	N	n/a	25	n/a
57 (KG)	1/28/2021	17:47	17:54	0:07	17:39	17:58	N	n/a	19	n/a
58 (MRT)	1/29/2021	16:06	16:05	-0:01	15:59	16:21	N	n/a	22	n/a
59 (TG)	1/29/2021	18:37	18:34	-0:03	18:31	18:46	Y	19:50	15	79
60 (AK)	1/30/2021	11:59	11:57	-0:02	11:48	*	N	n/a		n/a
61 (CJ)	1/30/2021	15:07	15:05	-0:02	15:04	15:27	N	n/a	23	n/a
62 (BL)	2/2/2021	15:17	15:18	0:01	15:07	15:27	N	n/a	20	n/a
63 (JH)	2/3/2021	11:53	11:47	-0:06	11:48	12:02	N	n/a	14	n/a
64 (KD)	2/3/2021	13:08	12:52	-0:16	12:46	13:06	N	n/a	20	n/a
65 (JR)	2/3/2021	13:09	13:11	0:02	12:51	13:26	N	n/a	35	n/a
66 (DG)	2/3/2021	14:33	14:33	0:00	14:28	14:47	N	n/a	19	n/a
67 (SP)	2/3/2021	20:59	20:58	-0:01	20:41	21:18	N	n/a	37	n/a
68 (JB)	2/4/2021	5:26	5:30	0:04	5:17	5:31	N	n/a	14	n/a
69 (DG)	2/4/2021	14:43	14:43	0:00	14:33	14:48	N	n/a	15	n/a
70 (ST)	2/4/2021	16:40	16:34	-0:06	16:39	16:52	N	n/a	13	n/a
71 (DT)	2/6/2021	11:28	11:28	0:00	11:19	13:47	N	n/a	148	n/a
72 (CH)	2/7/2021	8:33	8:29	-0:04	8:30	8:40	N	n/a	10	n/a
73 (EH)	2/8/2021	12:55	12:41	-0:14	12:50	13:04	N	n/a	14	n/a
74 (NC)	2/10/2021	10:18	10:16	-0:02	10:08	10:31	N	n/a	23	n/a
75 (JJ)	2/10/2021	14:44	none		14:05	14:58	N	n/a	53	n/a
76 (CB)	2/12/2021	5:43	5:44	0:01	5:39	5:49	N	n/a	10	n/a
77 (TP)	2/13/2021	10:14	10:13	-0:01	9:28	10:31	N	n/a	63	n/a
78 (KP)	2/14/2021	17:55	17:54	-0:01	17:52	18:06	Y	18:31	14	39
79 (DJ)	2/14/2021	22:33	22:33	0:00	22:24	22:45	N	n/a	21	n/a
80 (PW)	2/15/2021	16:14	16:04	-0:10	15:46	16:18	N	n/a	32	n/a